
MANGANESE.

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THE ORES OF MANGANESE.

The commercial ores of manganese are almost universally oxides. At two locations, one in Merionethshire, in Wales, the other at Chevron, in Belgium, a carbonate is mined. The common ores of manganese, known as psilomelane, pyrolusite, braunite, and wad, are all oxides.

Three oxides of commercial importance are noted:

PROTOXIDE (MnO), known also as the monoxide or manganous oxide. Multiplying the amount of the protoxide or MnO in an ore by 0.7746 will give the contents of metallic manganese in the ore.

SESQUIOXIDE (Mn_2O_3), brown oxide, known also as manganic oxide. This oxide occurs in nature as braunite and in the state of hydrate as manganite ($\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$). Multiplying the amount of sesquioxide (Mn_2O_3) in an ore by 0.6392 will give the amount of metallic manganese in the ore.

PEROXIDE (MnO_2). Multiplying the amount of peroxide (MnO_2) in an ore by 0.63218 will give the amount of metallic manganese in the ore.

The common ores of manganese are as follows:

HAUSMANNITE is a form of the brown oxide, containing theoretically 72.1 per cent of metallic manganese.

PYROLUSITE, or binoxide, or black oxide of manganese is the most common of its ores used commercially, and is the peroxide. This is the name properly applied to the iron-black or shining dark steel-gray crystals. It generally occurs in minute crystals, grouped together and radiating from a common center. It is this variety that is chiefly used by glass makers, as in its crystallized form manganese ore contains the least iron.

PSILOMELANE, an impure peroxide or black oxide, allied to wad by containing water, is one of the most generally diffused of the ores of manganese. It is compact and fibrous, and has a dark steel-gray color and submetallic luster. It generally occurs in botryoidal or grapelike masses.

BRAUNITE is the brown or sesquioxide. It occurs massive and also crystallized. It is distinguished by its brownish color. It is one of the most common ores in the United States.

WAD is a hydrated peroxide or black oxide. It is not used at all in the United States. It sometimes occurs as a hard and compact ore, though usually in brownish-black masses loosely agglomerated.

There is a most intimate connection between the ores of iron and those of manganese, so intimate as to lead to manganese being at first regarded as an ore of iron. Its origin is evidently similar to iron, and its distribution is almost coextensive with the deposits of the brown hematite ores of this country. In almost all of these iron ores manganese occurs as a constituent. Sometimes the manganese displaces so much of the iron as to make the ore a manganiferous iron ore.

In close proximity to certain of the silver ores of the west, especially the carbonates of Leadville, iron and manganese ores carrying a percentage of silver are found. These ores, which have been termed manganiferous silver ores, are from the upper workings of Leadville, and carry manganese in varying quantities from 5 up to 25 per cent, and occasionally 30 to 35 per cent, with 5 to 20 ounces of silver, 0 to 4 per cent of lead, 7 to 18 per cent of silica, and 30 to 50 per cent of iron.

It should also be noted that the zinc ores of Sussex county, New Jersey, which are mined for zinc, contain considerable manganese. These zinc ores are a mixture of willemite, franklinite, zincite, and calcite. The residuum from working these ores for zinc, which may be termed manganiferous zinc ores, is used in blast furnaces in New Jersey and in eastern Pennsylvania for the manufacture of spiegeleisen.

The ores of manganese, or those carrying manganese, will be divided into 4 general classes: first, manganese ores; second, manganiferous iron ores; third, manganiferous silver ores, and fourth, manganiferous zinc ores. The dividing line between the first two grades is taken at 70 per cent binoxide of manganese, equal to 44.25 per cent metallic manganese, this being the standard of shipments to English chemical works. All ores containing at least this amount of manganese are classed as manganese ores; those containing a less percentage of manganese and containing also more or less iron are classed as manganiferous iron ore. In the third class are included the

manganiferous silver ores of Colorado, which are utilized chiefly for the silver they contain. They have an added value, however, by reason of the fluxing qualities imparted to them by the presence of manganese and iron. In the fourth class is placed the residuum or clinker from the zinc ores of New Jersey.

The ton used in this report is the long ton of 2,240 pounds if not otherwise designated.

MINING LOCALITIES IN THE UNITED STATES.

By far the larger proportion of the manganese ores proper produced in the United States is mined in 3 localities: Crimora (Virginia), Cartersville (Georgia), and Batesville (Arkansas).

Of the 24,197 tons of manganese produced in the census year, 20,325 tons were from these 3 districts. Manganese is found, however, in many places in the United States. For example, all along the western slope of the eastern ridge of the Appalachian range from Maine to Georgia more or less manganese has been mined. There is also some manganese ore found associated with the hematite ores of the Lake Superior region, and in Arkansas southwest from Batesville. With few exceptions, however, the deposits are small, and the indications are not such as to justify the expenditure of large amounts of money in mining and washing plants, which are usually necessary in the economical production of manganese. From one locality in Vermont, however, as will be seen by the report, considerable manganese has been produced, and there are mines in Virginia along the Shenandoah valley and its southern extension, as well as on the upper James, at which some manganese was produced in 1890, and which it is believed will add largely to its production in this country in the near future. A similar statement can be made of mines in Georgia.

The largest proportion of the manganiferous iron ores produced in the United States are from the Lake Superior region, and chiefly from the Gogebic district of Wisconsin and Michigan, where it is found associated with the iron ores of that section. Some manganiferous iron ore is mined in Virginia with manganese ores, but all the ore mined in that state in 1889 is classed as manganese. In Colorado quite an amount of manganiferous iron ore, in addition to the manganiferous silver ore, was produced in 1889 and used at Pueblo and at Chicago in the manufacture of spiegeleisen. All of this was from the Leadville district.

Most of the manganiferous silver ore mined in 1889 was from the Leadville district of Colorado.

All of the manganiferous zinc ores were from Sussex county, New Jersey.

PRODUCTION OF MANGANESE ORES.

In the following table will be found a statement of the production of manganese ores in the United States in 1889; also a statement as to its total value, the average value per ton, the number of employes, total wages of such employes, total capital, and the division of these items by states:

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES IN 1889.

STATES.	Production. (Tons.)	Total value.	Value per ton.	Number of employes.	Total wages paid.	CAPITAL INVESTED.				
						Total.	In land.	In build- ings and fixtures.	In tools, live stock, machinery, and sup- plies on hand.	All other items, including cash.
Total	24, 197	\$240, 559	\$9. 04	432	\$123, 958	\$2, 188, 950	\$1, 618, 650	\$98, 700	\$233, 750	\$237, 850
Arkansas.....	2, 528	23, 173	9. 17	96	33, 191	1, 215, 000	1, 100, 900	38, 500	35, 600	40, 000
California.....	53	901	17. 00	10	1, 149	2, 400	2, 000	400	-----	-----
Georgia.....	5, 208	50, 143	9. 63	117	19, 486	247, 350	163, 250	32, 800	21, 900	29, 400
Nevada.....	15	83	5. 53	2	53	600	-----	-----	-----	600
North Carolina.....	47	470	10. 00	2	160	250	-----	-----	-----	250
South Carolina.....	124	744	6. 00	6	400	5, 000	2, 500	750	250	1, 500
Tennessee.....	30	120	4. 00	3	70	100	-----	-----	-----	100
Vermont.....	1, 576	8, 668	5. 50	25	3, 510	7, 250	-----	1, 250	1, 000	5, 000
Virginia.....	14, 616	156, 257	10. 69	171	65, 939	711, 000	350, 000	25, 000	175, 000	161, 000

In the preceding table is included a very small amount of ore which, under strict classification, would be regarded as manganiferous iron ores, but as the metallic manganese in but few cases falls below 40 per cent they are all reported as manganese ores. Less than 1,000 tons of ore fall below 44.25 per cent of metallic manganese, and the average of the whole 24,197 tons is above this percentage.

Certain explanations of these statistics are necessary to prevent wrong deductions or conclusions. In but four instances, at the most, is manganese-ore mining prosecuted in the United States with anything like regularity, and in but two of the four was mining continuous. At the works producing the largest amount of manganese in Georgia the mines were operated but 190 days in the year, while at the Vermont mine during a large proportion of the year

but little work was done. At 1 mine in Virginia and 1 in Arkansas the mining of manganese is fairly continuous. At most of the other works the production reported has been from very irregular workings, and chiefly for the purpose of testing the character of the deposit. This is true of all the production of Tennessee, North Carolina, South Carolina, and Nevada, while the California production is from an old mine, worked occasionally to meet a small demand for manganese for the purpose of making chlorine gas in working sulphuret ores.

It will be judged from this statement, therefore, that the reports in the table as to the number of employes and wages paid simply refer in most cases to men who were employed for a very brief time, and who were in most instances common laborers picked up from farm and other work, returning to their ordinary occupations as soon as their temporary services in stripping manganese-ore deposits and in mining the small quantities of manganese reported were completed.

The item of capital includes not only the money actually invested in works, but also the value of the mine or mineral right. In some cases a high valuation is placed upon these rights. Future developments will be necessary to determine whether it is too high.

From the preceding table of the production of manganese it will be seen that 60.4 per cent of the manganese produced in the United States was from the mines of Virginia. Of this production 12,974 tons were from the well-known Crimora mine and the opening adjoining it, known as the Old Dominion mine. More manganese has been taken from these mines, which are practically the same deposit, than from all the rest of the United States, and it is probably fair to say that this deposit has produced more than any other mine in the world. The grade of the ore is somewhat above the limit dividing manganese and mangiferous iron ore, the average shipments for 1889 showing 46 per cent metallic manganese.

Georgia stands second in point of production. Of the 5,208 tons produced in this state in 1889 over 4,000 tons were from the mines of 1 company.

Arkansas stands third in point of production, and here again by far the larger proportion of the ore produced was from 1 mine. The fourth state in point of production of manganese was Vermont, 1,336 tons being produced from 1 mine. As is noted above, the production of manganese in other states has chiefly been in an experimental way.

PRODUCTION OF MANGANIFEROUS IRON ORES.

A large proportion of the hematite iron ores of the United States carry more or less manganese. While in most cases the amount of manganese in these ores does not increase their value over what the same ores would be worth as iron ores were the manganese absent, they, however, make the ore more desirable for certain purposes. No attempt has been made to collect the statistics of these manganese-bearing iron ores except in cases where the manganese in them has added somewhat to their value.

A product of 31,341 tons of ore, containing on an average 9 per cent of manganese, is reported from Michigan, and a further product of 50,018 tons of ore, containing 6.74 per cent of manganese, is reported for the same state, making a total of 81,359 tons of iron ore produced in Michigan containing sufficient manganese to make it desirable to be mined. The value of this ore is reported at \$3.25 per ton.

In Colorado 2,075 tons of mangiferous iron ores, used in the manufacture of spiegeleisen, were produced in 1889. This was valued at \$3.50 per ton.

The total production of mangiferous iron ores in the United States in 1889 was as follows:

PRODUCTION OF MANGANIFEROUS IRON ORES IN THE UNITED STATES IN 1889.

STATES.	Production. (Tons.)	Total value.	Value per ton.
Total	83,434	\$271,680	\$3.26
Michigan, containing 9 per cent of manganese and over	31,341	101,858	3.25
Michigan, containing 6.74 per cent of manganese	50,018	162,559	3.25
Colorado, containing 20 per cent of manganese and over	2,075	7,263	3.50

It is impossible to give any statement as to the number of employes, amount of wages, or capital invested in the production of this ore, as these items are included in the report on the iron-ore or silver production of the mines supplying it.

PRODUCTION OF MANGANIFEROUS SILVER ORES.

The only district producing manganiferous silver ores in 1889 was Leadville, Colorado. It has been estimated that from 300 to 500 tons of this ore are produced per day. On the basis of the lowest figures, that is, 300 tons a day for 300 days in the year, the production of manganiferous silver ore in the Leadville district would be 90,000 tons. The actual statements received show a product of 64,987 tons, of an average value of \$3.50.

PRODUCT OF MANGANIFEROUS SILVER ORES IN THE UNITED STATES IN 1889.

Colorado 20 per cent of manganese and over (tons).....	9,987
less than 20 per cent of manganese (tons).....	55,000
Total (tons).....	64,987
Total value.....	\$227,455.00
Value per ton.....	3.50

MANGANIFEROUS ZINC ORES.

In Sussex county, New Jersey, a zinc ore carrying considerable percentage of manganese is produced. This ore is first utilized for its zinc; the residuum, or clinker, as it is called, is then used in the production of spiegeleisen, the first spiegel made in the United States (in 1870) having been produced from these ores. The production of this manganiferous zinc residuum (or, better, the amount used in the production of spiegel) in 1889 was 43,648 tons, valued at \$1.25 per ton, containing on an average about 11 per cent of manganese and producing 14,124 tons of spiegeleisen.

Owing to the fact that this manganiferous zinc ore is simply a residuum or by-product in zinc smelting, it is impossible to give any other statistics concerning it than the simple tonnage produced and the value of the same at the zinc furnaces. The capital invested, the number of employes, and the wages paid in the production of this clinker are given in connection with the report on the production of metallic zinc.

PRODUCTION AND VALUE OF ALL CLASSES OF MANGANESE ORES MINED IN THE UNITED STATES IN 1889.

In the following table are grouped the statements showing the total production and value of all classes of manganese ores mined in the United States in 1889. The manganiferous iron ores mined in the Lake Superior district and those mined in Colorado will also be reported upon in the iron-ore report. The manganiferous silver ores will be mentioned also in the report on silver ores, though as the manganese contained is much larger in percentage than the silver, they are spoken of as manganese or manganiferous ores, and not silver ores.

TOTAL PRODUCTION AND VALUE OF ALL CLASSES OF MANGANESE ORES MINED IN THE UNITED STATES IN 1889.

[Tons.]

CLASSES OF ORES.	Production. (Tons.)	Total value.	Value per ton.
Total	216,266	\$794,254	\$3.67
Manganese ores.....	24,197	240,559	9.94
Manganiferous iron ores.....	83,434	271,680	3.26
Manganiferous silver ores.....	64,987	227,455	3.50
Manganiferous zinc ores.....	43,648	54,560	1.25

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES SINCE 1880.

The production of manganese from 1880 to 1889, inclusive, was as follows:

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES.

[Tons.]

STATES.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
Total.....	5,761	4,895	4,532	6,155	10,189	23,258	30,193	34,524	29,198	24,197
Virginia.....	3,661	3,295	2,982	5,355	8,980	18,745	20,567	19,835	17,646	14,616
Arkansas.....		100	175	400	800	1,483	3,316	5,651	4,312	2,528
Georgia.....	1,800	1,200	1,000			2,580	6,041	9,024	5,568	5,208
Other states.....	300	300	375	400	400	450	269	14	1,672	1,845

The preceding table shows the production of what may be strictly regarded as manganese ores in the classification before given. It has been impossible in some cases to separate the manganese and manganiferous

ores which are the product of a given mine, but where the total production of state or mine averages more than 44.25 per cent of metallic manganese its production is regarded as manganese ores.

The data necessary to show the production of all classes of manganese ores do not go farther back than 1880.

THE WORLD'S PRODUCTION OF MANGANESE IN 1888 AND 1889.

The following statement from Messrs. Macqueen Bros., of London, the largest dealers in manganese in the world, shows the imports of high-grade manganese, that is, manganese ore containing from 45 to 55 per cent of metallic manganese, into European countries in 1888 and 1889:

IMPORT AND EXPORT MOVEMENTS OF MANGANESE ORE IN 1888 AND 1889.

[Tons.]

COUNTRIES.	1888.	1889.
Imported into—		
Great Britain.....	74,906	99,062
France.....	6,174	4,584
Belgium.....	1,945	3,125
Germany.....	9,624	12,431
Total.....	92,649	119,202
Exported from—		
Caucasus (Russia).....	48,653	55,383
Chile.....	24,746	25,915
Spain.....	2,830	} 17,241
Portugal.....	5,638	
Turkey.....	669	} 8,329
Greece.....	500	
Italy.....	385	
Sweden.....	6,089	8,320
Australia.....	1,572	} 2,284
New Zealand.....	787	
Canada.....	248	
Austria.....		1,247
Other countries.....	532	483
Total.....	92,649	119,202

To arrive at the world's product there should be added to the above the product of the United States, Great Britain, France, Belgium, Germany, Cuba, and the Canadian ore that comes to the United States. Taking the latest available figures of production, and where these figures are not for 1888 or 1889 regarding them as approximately the product of that year, the following is the estimated total product of manganese in the world in 1888 and 1889:

TOTAL PRODUCT OF MANGANESE IN THE WORLD IN 1888 AND 1889.

[Tons.]

COUNTRIES.	1888.	1889.	COUNTRIES.	1888.	1889.
Caucasus (Russia).....	48,653	60,000	Greece.....	385	400
United States.....	29,198	24,197	Italy.....	1,652	400
Chile.....	24,746	5,000	Cuba.....	1,581	4,000
France (1886).....	7,676	} 18,000	Other countries.....	3,114	1,000
Sweden.....	6,089		Nova Scotia.....	106	200
Portugal.....	5,638		New Brunswick.....	1,094	1,000
Spain.....	2,830		Quebec.....	3	
Australia.....	1,572	9,000	Great Britain (1887)...	13,054	10,000
New Zealand.....	787		Bosnia.....	4,000	2,000
Turkey.....	669	8,000	Holland.....	1,167	800

PRODUCTION BY STATES.

ALABAMA.

No manganese nor manganiferous iron ores were mined in Alabama in 1889. In the brown hematite iron ore beds of this state, as in similar deposits in other localities in the Appalachian region, a manganiferous iron ore is often found. As early as 1875 one of these deposits of ore was utilized by the Woodstock Iron Company, of Anniston, Calhoun county, in the manufacture of spiegeleisen. The ores in the neighborhood of Woodstock occur, as is stated, as a constituent of iron ore, sometimes as veins and crusts resting upon the iron ore, at others in chimneys or pockets in the ore belt or vein. These crusts vary in thickness from 1 to 3 feet. Analyses of such a deposit are given on the following page.

ANALYSES OF MANGANIFEROUS BROWN HEMATITE IRON ORE
NEAR WOODSTOCK, ALABAMA.

COMPONENT PARTS.	No. 1.	No. 2.
	Per cent.	Per cent.
Metallic iron.....	38.59	41.76
Metallic manganese.....	11.44	13.68
Silica.....	11.45	24.65
Phosphorus.....	0.27	0.55
Combined water.....	11.62	19.66

As a rule, in mining iron ore no attempt is made to separate the manganiferous portions, but both grades are charged into the furnace together. The proportion of manganese in the charge is small, but sufficient to give the cinder the greenish tinge indicative of its presence.

In a paper read before the American Institute of Mining Engineers on the geology of Alabama by Mr. E. J. Schmitz, of New York, the following analyses of manganese ores from this state are given. It is evident that these ores can not exist in any quantities or certainly some use would have been made of them, rich as the analyses show them to be.

ANALYSES OF MANGANESE ORES FROM ALABAMA.

No.	VARIETIES.	Formation.	County.	Analyst.	Per cent of peroxide of manganese.	Specific gravity.
1	Pyrolusite.....	Metamorphic.....	Chilton.....	Endemann.....	71.22	.....
2	Pailomelane.....	Silurian.....	Talladega.....	Mallet.....	62.43	3.712
3	Pailomelane.....	Metamorphic.....	Randolph.....	Mallet.....	63.25	3.988

The only ore shipped from this state was from Stocks Mills, in Cherokee county, late in 1886, by Messrs. Kelly & Webb. Their operations showed the existence of a series of small pockets yielding ore quite low in phosphorus, analyzing about 45 per cent of manganese, 0.08 per cent of phosphorus, 5 per cent of iron, and 8 per cent of silica. Only about 75 tons were mined.

The ore at the furnace of the Woodstock Iron Company at Anniston is stated by Professor William P. Blake to have contained about 20 per cent of metallic manganese and no phosphorus. Professor Blake's analyses of the spiegeleisen made at this furnace from December 10, 1875, to February 3, 1876, are as follows:

ANALYSES OF SPIEGELEISEN MADE IN ALABAMA.

COMPONENT PARTS.	December 10.	January 6.	February 1.	February 3.
	Per cent.	Per cent.	Per cent.	Per cent.
Iron.....	85.11	85.98	80.37	73.86
Carbon.....	3.66	4.83	4.94	4.32
Silica.....	0.95	0.88	0.38	0.93
Phosphorus.....	0.10	0.17	0.18	0.18
Manganese.....	10.18	8.14	14.13	20.69

ARKANSAS. (a)

Manganese ores are found in 2 localities in Arkansas, 1 known as the Batesville region, chiefly in Independence and Izard counties, in the northeastern part of the state, and the other in the southwestern part of the state, extending from Pulaski county on the east to Polk county and Indian territory on the west. But little work has been done in the southwestern district, and that principally in the way of development. The Batesville or northeastern district has furnished all of the ore produced commercially in Arkansas.

The existence of manganese in the Batesville region has been known for over 40 years, but it is only since 1881 that it has been mined on a commercial scale. Colonel Matthew Martin mined and shipped small quantities of these ores to Boston, New York, and Philadelphia as early as 1850 to 1852. One shipment is said to have been made to Liverpool, where it was used in Tennant's Glasgow chlorine works. As there were no railroads in the country at that time, the ore was hauled in wagons to the White or Black river, whence it was shipped by barges to New Orleans, and then transferred for Liverpool.

Though shipments were made thus early, a few hundred tons would probably include the total quantity produced up to 1868. In that year Mr. William Rinstein, of Saint Louis, made the first shipment of manganese

^a In volume I of the annual report of the geological survey of Arkansas for 1890 will be found a very complete and detailed description of the occurrence of manganese ores in Arkansas, by Dr. R. A. F. Penrose, Jr.

from Arkansas for steel purposes. This was sent to Messrs. Schoenberger & Co., of Pittsburg, Pennsylvania. The shipment was 10 tons, and was sold at Pittsburg for \$30 per ton. From this time until 1881, when Mr. E. H. Woodward began operations in Arkansas, but little was done. From this date to 1887 the shipments amounted, it is estimated, to 5,000 tons or more. In October, 1885, the Keystone Iron and Manganese Company, of Pennsylvania, acquired large tracts of land, and have since been the largest shippers of ore from Arkansas, the total production up to December 31, 1891, being 18,111 tons. Other companies have since begun operations, but at present the output is quite small.

Batesville, from which the district takes its name, is a town of some 2,000 inhabitants, situated on the White river, and is the county seat of Independence county. A branch railroad runs from Newport, on the main line of the Iron mountain division of the Missouri Pacific, to Batesville. By this road and its branches the distance from Batesville to Saint Louis is 291 miles; to Cairo, 191 miles. The distance from Saint Louis to Pittsburg is 621 miles; to Chicago, 282 miles.

The manganese belt at Batesville is somewhat elliptical in shape, and has a length from east to west of about 16 miles, with an average breadth of about 3 miles. In this distance, however, the ore is by no means continuous, there being frequent interruptions and many places from which the ore is absent. It is probable that 7 or 8 square miles would cover the ascertained extent of the deposits. In its topography the ore district is an irregularly located group of rounded hills 100 to 500 feet above the general drainage level of the country. Two creeks run through the belt, Polk bayou on the east and Lafferty creek on the west. The ore belt is by no means well watered, however, and there is considerable difficulty in securing sufficient water for washing.

Geologically the country exhibits a monoclinic structure, dipping gently to the southeast from Lafferty creek toward Batesville. The main portion of the hills above water level are subcarboniferous limestone, covered with wash and crowned with broken chert or flint. Underneath the limestone is sandstone.

The ores occur in two horizons and under two distinct conditions:

1. The drift ores of the northwestern portion of the region.
2. The regular stratified bed of the eastern portion of the belt.

The drift manganese ore is found under the tops of the hills, in pieces from the size of a pea up to boulders 2 and 3 and even 4 tons in weight. The diluvial deposit carrying the ore is from 5 to 25 feet in thickness, averaging, say, 9 feet, and rests upon a floor of limestone, a brown clay of varying thickness being interposed. This ore drift yields from 12 to 30 per cent of ore. Above the manganese drift is an earthy wash, interspersed with fragments of chert from 3 to 30 feet thick. At the Southern mine, from which over 5,000 tons have been taken, the stripping is 2 to 25 feet thick, and the drift in which the manganese is found 20 feet thick. The pit at this mine covers a little more than half an acre. At other pits opened the stripping is 10 feet and the ore drift 5 to 11 feet.

The source of the manganese ore lumps is believed to be the "cavernous limestone" found to the northwest of the ore belt, which originally occupied greatly elevated positions. Some of the formation near the mouth of Lafferty creek which has escaped the denuding agencies still carries veins of manganese ore 8 to 14 feet thick.

The ore, which is the black oxide, varies in quality from 40 to 60 units of metallic manganese, is of a bright luster, submetallic in color, subcrystalline, brittle, and with a fracture like that of cast iron. The following is the average of thorough analyses of 7 shipments:

AVERAGE COMPOSITION OF 7 ANALYSES OF BATESVILLE, ARKANSAS, MANGANESE ORE.

	PER CENT.
Metallic manganese.....	50.43
Metallic iron.....	3.66
Phosphorus.....	0.16
Water.....	2.28

A recent analysis shows the following constituents:

ANALYSIS OF BATESVILLE, ARKANSAS, MANGANESE ORE.

	PER CENT.
Manganese.....	58.76
Iron.....	3.75
Phosphorus.....	0.14

Analyses from 3 separate pits show the following:

ANALYSES OF BATESVILLE, ARKANSAS, MANGANESE ORES.

COMPONENT PARTS.	Pit 1.	Pit 2.	Pit 3.
	Per cent.	Per cent.	Per cent.
Metallic manganese.....	56.92	54.33	56.88
Phosphorus.....	0.10	0.29	0.18
Insoluble matter.....	2.10	1.54	0.72

A drift ore gave the following:

ANALYSIS OF BATESVILLE, ARKANSAS, DRIFT MANGANESE ORE.

	PER CENT.
Metallic manganese.....	55.95
Phosphorus.....	0.17
Insoluble matter.....	1.27

The mining cost depends chiefly on the amount of stripping and the percentage of ore in what is termed the "manganese ore drift". From 2 to 5 tons of earth must be removed for every ton of ore obtained, and the drift yields from 12 to 30 per cent of ore. Probably \$2.50 will fully cover the mining cost.

The second body of ore is found between the buff-colored sandstone of Batesville and the subcarboniferous limestone which forms the floor of the deposits above noted; that is, the first-named deposit rests upon the limestone, the second underlies it, or, perhaps better, is in the horizon of transition between the limestone and the sandstone underlying it. This is a most peculiar deposit. The ore occurs in buttons or concretions imbedded in a red matrix of lean siliceous iron ore, the matrix adhering so closely to the "buttons" as to preclude so far all attempts to separate it from the rich manganese in the "buttons". The matrix splits up into rusty slabs 2 to 4 or 5 inches thick. This ore has but little commercial value. An average analysis of this deposit is as follows:

AVERAGE ANALYSIS OF "BUTTON" MANGANESE ORE FROM BATESVILLE, ARKANSAS.

	PER CENT.
Metallic manganese.....	16.46
Metallic iron.....	8.70
Phosphorus.....	0.60
Insoluble matter.....	43.65

The manganese deposits of southwestern Arkansas, as has already been stated, extend from Pulaski county on the east to Polk county on the west. This area varies in width from 4 or 5 to 10 or 12 miles, and in length is about 125 miles. It is not to be inferred, however, that manganese is found everywhere throughout this belt. It exists in a series of pockets, separated more or less widely by barren rocks. The lack of transportation facilities, as well as the excessively "pockety" character of the ores, has made all attempts to develop the deposits on a commercial scale failures.

The ores are oxides of manganese in their different mineralogical forms. The general course of the veins is from east to west. Analyses of surface specimens made by Professor W. B. Potter and Regis Chauvenet & Bro., of Saint Louis, give the following results:

ANALYSES OF POLK COUNTY, ARKANSAS, MANGANESE ORE.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	Per cent.	Per cent.	Per cent.
Silica.....	9.62	3.75	1.88	3.28
Iron.....		0.50	35.39	4.40
Metallic manganese.....	58.36	55.80	27.68	52.22
Phosphorus.....	0.41	0.63	0.13	0.04

A more detailed analysis of No. 4 is as follows:

	PER CENT.
Moisture.....	0.441
Silica.....	3.287
Alumina.....	2.370
Calcium oxide.....	1.864
Magnesium.....	0.512
Phosphorus.....	0.044
Iron.....	4.403
Manganese.....	52.225
Binoxide of manganese in ore.....	69.832

An analysis of a soft ore taken from a shaft in the central part of this county gives 60.28 per cent metallic manganese and 0.17 per cent phosphorus. The specimens run from 60 to 70 per cent in binoxide and from 15 to 23 in the sesquioxide of manganese. Assays of 26 specimens sent to Birmingham and Sheffield, England, gave the first of the analyses on the following page.

ANALYSES OF MANGANESE ORE FROM POLK COUNTY, ARKANSAS.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Silica	3.00	2.766	1.190	
Iron			2.696	
Metallic iron				17.09
Metallic manganese	53.10	71.29	54.250	47.00
Phosphorus	0.13	Trace.	0.09	0.05

No. 2 is the average of 4 assays by Professor Waite, of the Missouri School of Mines. No. 3 is by Professor J. Blodgett Britton, of Philadelphia. No. 4 was made at the Smithsonian Institution.

Arkansas ranks the third state in the Union as a producer of manganese, it being exceeded by Virginia and Georgia. The statistics of the production for 1889 are given in the following table:

STATISTICS OF THE PRODUCTION OF MANGANESE IN ARKANSAS IN 1889.

Total production (tons)	2,528
Total value	\$23,173
Value per ton	\$9.17
Number of employés	96
Total wages paid	\$33,191
Total capital invested in land, etc., and employed in business	\$1,215,000
Capital invested in land	\$1,100,900
Capital invested in buildings and fixtures	38,500
Capital invested in tools, implements, live stock, machinery, and supplies on hand	35,600
Capital invested in other items, including cash	40,000

The work at most of the mines in this district was of such a desultory character that it is not possible to give any statement as to the average number of men employed and wages paid per day. The best average of wages that could be arrived at is as follows:

	PER DAY.
Manager of mines	\$3.33
Foremen or overseers	1.75
Mechanics	1.75
Miners	1.25
Laborers	1.10
Boys under 16 years	0.50

The production of manganese in Arkansas since the beginning of shipments in 1850, as far as the same can be ascertained, is given in the table following, together with the authority for the same. It has been estimated that the production of manganese in Arkansas prior to 1885 was 5,000 tons, but this may be questioned. The figures of production from 1881 to the close of 1884 are from the railroad reports of shipments. The figures from 1885 to 1888 are from the annual volume of Mineral Resources of the United States, while those of 1889 are the census figures. The figures from 1885 to 1889 have also been verified by the statements of shipments from the different points along the line of the Iron mountain division of the Missouri Pacific, which have been kindly furnished by the officers of that road.

PRODUCTION OF MANGANESE IN THE BATESVILLE DISTRICT OF ARKANSAS
TO DECEMBER 31, 1889.

YEARS.	Authority.	Tons.
1850 to 1868	Estimated	499
1868	do	19
1881	Railroad reports of shipments	190
1882	do	175
1883	do	499
1884	do	899
1885	Mineral Resources of the United States	1,483
1886	do	3,316
1887	do	5,651
1888	do	4,312
1889	Census	2,528

CALIFORNIA.

Manganese mining is an industry of but little importance in California. There is a small demand for the ore, chiefly for the manufacture of chlorine gas to be used in working sulphuretted gold ores.

It is reported that the first manganese mining in California was done in 1867 by Mr. A. S. Ladd at Corral Hollow, Alameda county. Operations were carried on by Mr. Ladd until 1874. The ore mined, which is said to have amounted to 5,000 tons, was shipped to England and used in chemical manufacture. Since 1874, at which date Spanish manganese began to be imported into England, the market for the California manganese has been limited, and but little has been produced. The Ladd mine was purchased in 1874 by Mr. Justinian Caire, who produces a small amount each year, the production for 1889 being but 53 tons, running from 56 to 72 per cent of pyrolusite, and worth about \$17 per ton. This was the only manganese produced in California in 1889. The ore at this mine, when fresh, is a hard, black, massive variety, occurring in a lenticular bed interstratified in red, yellow, and gray jasper.

An analysis of the manganese from the Corral Hollow mine is as follows:

ANALYSIS OF MANGANESE FROM CORRAL HOLLOW, CALIFORNIA.		PER CENT.
Manganese protoxide (MnO).....		75.26
Oxygen (O).....		6.94
Ferric oxide (Fe ₂ O ₃)		3.26
Cobalt oxide (CoO)		Trace.
Lime (CaO).....		3.10
Baryta (BaO).....		None.
Magnesia (MgO).....		0.56
Potash (K ₂ O)		0.19
Soda (Na ₂ O)		0.58
Water (H ₂ O).....		8.46
Silica (SiO ₂)		1.98
Total.....		100.33

Other deposits of manganese are known to exist in California, but they are at present of no commercial importance.

The statistics of the production of manganese in California in 1889 are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN CALIFORNIA IN 1889.	
Total production (tons)	53
Total value.....	\$901
Value per ton at San Francisco.....	\$17
Number of employes	10
Total wages paid	\$1,149
Total capital invested in lands, etc., and employed in business.....	\$2,400
Capital invested in land	\$2,000
Capital invested in buildings and fixtures	400

Regarding the total production of the state but little can be said. A prominent dealer on the coast reports, as published in the volume of Mineral Resources of the United States, 1886, that the total amount used in California was from 100 to 150 tons annually, the value at the mine being from \$3 to \$4 per ton for ore carrying from 50 to 60 per cent manganese. The price given for the ore mined in 1889, \$17 per ton, was for ore delivered in San Francisco. If, as is stated above, 5,000 tons of ore were mined in this state up to 1874, it is possible that 6,000 tons of manganese may have been produced in California from the beginning of mining.

COLORADO.

Colorado produces two classes of manganese-bearing ores, a manganiferous iron ore, used to some extent in the production of spiegeleisen, and a manganiferous silver ore, used as a flux in the smelting of silver-lead ores. The manganiferous iron ores carry as a rule but little silver, though in some cases the content of silver has been so high as to justify the working for silver of the slags produced at the blast furnaces at the time they were running on spiegeleisen.

These ores are all from the upper workings of the Leadville silver deposits, and carry manganese in varying quantities, from 5 up to 25 per cent, and occasionally 30 to 35 per cent, with 0 to 20 ounces of silver, 0 to 4 per cent of lead, 7 to 18 per cent in silica, and 30 to 50 per cent of iron.

As stated above, those high in manganese and low in silver are sold to steel works for the manufacture of spiegeleisen, while those carrying silver and not too high in silica are sold to the silver smelters and paid for according to the content of silver. It is usual for the smelters to buy these ores according to their so-called "silica excess", that is, the excess of iron and manganese over silica. This "silica excess" was placed in 1889 at 40 per cent; that is, there must be an excess of 40 per cent of manganese and iron over the silica in the ore, and it

is then accepted and paid for, not according to its iron and manganese contents, but its silver. When the "excess" is above 40 per cent the excess is paid for at 10 cents a unit. Thus an ore with the following composition, viz, metallic manganese 25 per cent, metallic iron 30 per cent, silica 2.5 per cent, and silver 5 ounces, would have an excess of iron over silica of 52.5 per cent, or 12.5 per cent above the 40 per cent minimum excess. This, at 10 cents a unit, would be \$1.25; the 5 ounces of silver, at 45 cents an ounce, would be \$2.25, and the ore would be worth \$3.50. It will not pay to produce these ores at less than \$3.50, free on board at mines.

It has been estimated that from 300 to 500 tons of this ore are produced per day. On the basis of the lowest figures, that is, 300 tons a day for 300 days in the year, the production of mangiferous silver-iron ore in the Leadville district would be 90,000 tons.

The actual shipments to spiegel furnaces in 1889 were 2,075 long tons. It is estimated that in addition to this 9,987 tons, containing over 20 per cent of manganese, were sold as flux ores, and returns of the sales of some 55,000 tons of flux ores carrying less than 20 per cent of manganese have been received. This would make the production in 1889 as follows:

PRODUCTION OF MANGANIFEROUS ORES IN COLORADO IN 1889.

	TONS.
Manganiferous iron ores used for spiegeleisen.....	2,075
Manganiferous silver ores with 20 per cent and over of manganese.....	9,987
Manganiferous silver ores with less than 20 per cent of manganese.....	55,000
Total	67,062

As these ores were not produced as manganese ores, no returns of capital, employes, etc., can be given. Analyses of these ores carrying 20 per cent and over of manganese are as follows:

ANALYSES OF MANGANIFEROUS IRON ORES IN COLORADO.

COMPONENT PARTS.	Catalpa.	Crescent No. 1.	Crescent No. 2.	Hall.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	34.90	17.89	21.15	35.00
Silica	6.90	6.30	7.60	3.83
Manganese	21.30	34.00	31.60	19.30
Alumina.....	4.15			2.00
Lime	0.34			0.46
Magnesia.....	0.07			0.45
Sulphur	0.06	0.027		
Phosphorus.....	0.04	0.056		
Copper	Trace.			0.03
Oxide of lead				1.85
Volatile matter				0.36
Water				2.96

CONNECTICUT.

Manganese ore in small quantities is frequently found in connection with the iron ores of the Salisbury district, though no manganese is ever produced separately. Attempts have been made to find the manganese ore in this district in sufficient quantities to pay for separating it from the iron ore, and though small quantities have been found from time to time, it never has been sufficient to pay for separation.

GEORGIA.

One of the oldest and most continuously worked as well as one of the most important of the manganese ore-producing districts in the country is what is known as the Cartersville district, in Georgia. It is located in the northwestern part of the state, in Bartow county, the deposits extending into Cherokee county. Manganese was first mined here, so far as there are any records, in 1866 by the Pyrolusite Mining Company, 550 tons of ore having been mined and sold in that year.

In addition to the deposits in the neighborhood of Cartersville, some deposits have also been found elsewhere in the state, notably in what is known as the Cave Springs district and the Tunnel Hill mine, in the extreme northwestern portion of the state.

All of the deposits of manganese in this state resemble each other in the association of manganese with brown hematite and the general character of the ores. The pockets in which the ores of the Cartersville district are found are in closer proximity than those of any other part of the state, and the amount seems to be greater. Indeed, it is only the Cartersville district that is a producer of manganese on a commercial scale.

In its topography the Cartersville district is broken or knobby. The elevations, however, rarely exceed 200 feet above the drainage level of the country. The district is quite well watered by the Etowah river and its tributaries;

the manganese deposits, however, are so situated as to make it difficult to secure water for washing. The belt in which the manganese is found is some 12 miles long by 3 miles wide, though the explorations do not as yet justify any definite conclusions as to the extent of the deposits.

The ore occurs in pockets, the matrix appearing to be a residual clay, the result of the decay of the rock in place. The occasional regularity of the deposits is perhaps due to the concentration of the ore along certain strata, all traces of stratification being subsequently obliterated by the decay of the rock. The ore is frequently accompanied by fragments of sandstone, and is nowhere observed in proximity to any other rock.

The ore occurs in massive, crystallized, and needle forms, and is found in grains from the size of a mustard seed to that of a pea and even a walnut, and also in much larger masses. The ore varies greatly, not only in percentage of ore to gangue found in the pockets in which it occurs, but also in its richness. In the same mines some ore will run as high as 60 per cent metallic manganese, in exceptional cases even higher, while on the other hand pieces as low as 38 per cent are found.

The method of mining varies with the locality, and there can not be said to be any definite system. Sometimes the pockets of ore are worked by open cuts, sometimes by tunneling from the cuts or from the shaft. The method of washing the ore now in general use is to rotate it in a horizontal cylinder, into which water is admitted. These cylinders are made either with boiler-iron jackets and lined with cast iron, or else of iron slats running longitudinally with sixteenth-inch interstices between them. This method saves all but the very smallest particles of the ore.

The oldest mine now operated in this district, and the one which has produced the most ore, is what is known as the Dobbins mine. Mining began here in 1867, possibly in 1866, and has been carried on at intervals ever since. The ore is quite good, as will be seen from the following analyses:

PARTIAL ANALYSES OF MANGANESE ORE FROM DOBBINS MINE,
CARTERSVILLE, GEORGIA.

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	52.726	48.832
Metallic iron.....	4.490	5.490
Silica.....	4.300	5.050
Phosphorus.....	0.188	

The largest producer of manganese in this district in recent years has been the Dade mine. This deposit shows all the usual characteristics of the Cartersville district as described above. The ore varies greatly in its composition, and the pockets in which the ore has been found as greatly in the production. Some years the mine has produced but 100 tons; in others the production has reached nearly 4,000 tons. A series of analyses of ore from this mine is given in the following table:

ANALYSES OF MANGANESE ORE FROM THE DADE MINE, BARTOW COUNTY, GEORGIA.(a)

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Silica.....	6.370	7.560	17.490	7.520	11.370	9.450	12.300	17.370	20.151	14.199	16.459
Iron.....	23.900	15.836	3.286	11.055	10.956	25.250	8.534	4.216	6.292	10.341	4.267
Manganese.....	59.320	36.489	49.354	41.439	36.950	27.711	42.933	42.612	41.055	39.228	43.457
Phosphorus.....	0.100	0.089	0.119	0.215	0.167	0.123	0.109	0.106	0.134	0.179	0.103

a All samples dried at 212°. Some ores run as low as 5 per cent manganese and 46 per cent iron.

Analyses from other mines in this district are given below:

ANALYSES OF MANGANESE ORE FROM ETOWAH, GEORGIA.

COMPONENT PARTS.	From lot No. 303.	From lot No. 391.
	<i>Per cent.</i>	<i>Per cent.</i>
Manganese dioxide.....	87.960	87.600
Oxides of iron and alumina.....	2.520	9.135
Sulphur.....	0.008	0.010
Phosphorus.....	0.120	0.065
Silica.....	8.350	2.175
Water and organic matter.....	1.042	1.015
Total.....	100.000	100.000
Metallic manganese.....	54.975	54.750

ANALYSIS OF MANGANESE ORE (RUN OF MINE) FROM THE MINES OF LARKIN SATTERFIELD,
CARTERSVILLE, GEORGIA.

	PER CENT.
Metallic manganese.....	44.72
Metallic iron.....	5.19
Silica.....	17.03
Phosphorus.....	0.15
Water.....	9.20

As has already been stated, the first ferro-manganese produced in the United States as a commercial product was made at the Diamond furnaces, on Stamp creek, near Cartersville, in 1875 by Mr. Willard P. Ward. It is also claimed that this was the first economic success in the manufacture of ferro-manganese in the blast furnace, methods of its production at blast furnaces in Europe prior to this date being extremely wasteful of the manganese in the ore. Mr. Ward produced ferro-manganese containing as high as 67 per cent of manganese.

The statistics of the production of manganese in Georgia in the census year are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN GEORGIA IN 1889.

Total production (tons)	5,208
Total value	\$50,143
Value per ton.....	\$9.63
Number of employes	117
Total wages paid	\$19,486
Total capital invested in lands, etc., and employed in business.....	\$247,350
Capital invested in lands	\$163,250
Capital invested in buildings and fixtures.....	32,800
Capital invested in tools, implements, live stock, machinery, and supplies on hand	21,900
Capital invested in other items, including cash.....	29,400

From reports received it would appear that wages are very small at manganese mines in this state. The average wages paid per day are as follows:

AVERAGE WAGES IN MANGANESE MINING IN GEORGIA.

	PER DAY.
Foremen or overseers	\$1.75 to \$2.50
Mechanics	1.25 to 1.50
Miners.....	1.10 to 1.60
Laborers.....	0.90 to 1.10
Boys under 16 years.....	0.50

The amount of manganese produced in Georgia has varied greatly, it having reached in 1887 9,024 tons, falling in 1888 to 5,568 tons and in 1889 to 5,208 tons. The following table gives, so far as the same has been ascertained, the production of manganese ore in Georgia since 1866. Most of this ore was produced in the Cartersville district.

PRODUCTION OF MANGANESE ORE IN GEORGIA FROM 1866 TO 1889, INCLUSIVE.

	TONS.		TONS.
1866.....	550	1878.....	2,400
1867.....		1879.....	2,400
1868.....		1880.....	1,800
1869.....		1881.....	1,200
1870.....	5,000	1882.....	1,000
1871.....		1883.....	.....
1872.....		1884.....	.....
1873.....		1885.....	2,580
1874.....	2,400	1886.....	5,981
1875.....	2,400	1887.....	9,024
1876.....	2,400	1888.....	5,568
1877.....	2,400	1889.....	5,208

LAKE SUPERIOR REGION.

Several years since a deposit of what promised to be a true manganese ore was found near Copper Harbor, and considerable money was spent in developing it. The quantity, amounting to several hundred tons of what was supposed to be manganese ore, was shipped to western Pennsylvania. Only about 100 tons, however, proved to be high enough in manganese to be classed as manganese ore. This was used in the furnaces of the Cambria Iron Company at Johnstown, Pennsylvania.

Analyses of Lake Superior ore that was used for its manganese are as follows:

ANALYSES OF MANGANESE ORES FROM NEAR COPPER HARBOR, MICHIGAN.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	49.14	46.33	46.26	37.17
Metallic iron.....	1.22	5.68	1.00	2.30
Phosphorus.....	0.02	0.02	0.01	0.03
Silica.....	12.90	12.79		17.56
Copper.....	2.21	1.60	0.98	1.05

At the McComber mine, at Negaunee, pockets of manganiferous iron ores are occasionally met with, some of which are 25 feet across and of a good quality. An analysis by Mr. Charles E. Wright of an average sample of this ore is as follows:

ANALYSIS OF MCCOMBER, MICHIGAN, MANGANESE ORES.

	PER CENT.
Oxide of iron.....	71.430
Oxide of manganese.....	17.250
Alumina.....	2.200
Phosphoric acid.....	0.073
Sulphuric acid.....	0.073
Silica.....	2.050
Water combined.....	5.320
Undetermined.....	1.604
	<hr/> 100.000 <hr/>
Metallic iron.....	49.800
Metallic manganese.....	10.900
Phosphorus.....	0.034
Sulphur.....	0.021

In 1877 advantage was taken of the fact that the Munising furnace was about blowing out for repairs to make a test of this ore for the manufacture of spiegeleisen, some 50 tons being charged. An analysis of the pig gave 10.60 per cent of manganese and 0.12 per cent of phosphorus.

While there are, strictly speaking, no manganese mines in the Gogebic region of Lake Superior, the ores from many of the mines in this district carry a small percentage of manganese. At times thin streaks of high-grade manganese ore are found in the iron-ore bodies. This has been notably the case in the mines that were formerly called the Bessemer and Bonnie, some samples of high-grade crystallized pyrolusite having been found.

While it is true that no mines in the Gogebic region are worked as manganese mines, at least 2 of the iron mines (the Colby and the Jackson) in this district graded the ore produced in 1889 into two or possibly three grades: first, iron ore proper; second, manganiferous iron ore containing 4 per cent and less of manganese; and, third, manganiferous iron ore containing 10 or 11 per cent of manganese.

The Colby mine, which has been the largest producer of this manganiferous iron ore, is in Ontonagon county, Michigan, near the Montreal river, which is the dividing line between Wisconsin and Michigan. The ore, which is a pronounced red hematite, as is most of the ore of this district, occurs in large lenses or pockets, some of which have a length of 1,000 feet and a width in places of 150 feet. At the Colby mine there are 2 ore zones, parallel to each other and about 150 feet apart. All of the iron ore in both of these zones carries a greater or less percentage of manganese, the average of the northern vein or zone being some 2 per cent of manganese, with 61 per cent of iron and 0.049 per cent of phosphorus; the southern vein or zone carries 4 per cent of manganese, with 59.30 per cent of iron and the same amount of phosphorus as the northern vein. In some cases, however, the manganese is as high as 33 per cent. During the year 1889 the Colby mine shipped 25,560 tons of ore which contained, per cargo samples, 54.60 per cent of iron and 8.92 per cent of manganese, and 50,018 tons of ore that contained 56.42 per cent of iron and 6.74 per cent of manganese.

Analyses of the ore from the Colby mine are as follows:

ANALYSES OF "BEAVER" MANGANIFEROUS IRON ORE FROM THE COLBY MINE, LAKE SUPERIOR.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron.....	54.898	57.784	54.549
Manganese.....	8.127	6.850	9.112
Silica.....	3.550	3.550	3.729
Phosphorus.....	0.064	0.071	0.062
Moisture.....	8.003	12.009	9.000

All of the preceding analyses were furnished by Mr. H. M. Curry, of Carnegie Brothers & Co., limited.

On the east side of one of the workings of the Jackson Iron Company a deposit of manganiferous iron ore is found. The deposit is very "pockety". Sometimes mining may be conducted for months without finding any manganese ore, and then a pocket will be struck which will yield a considerable quantity. In some years the mine has produced from 5,000 to 10,000 long tons, and in others it has run as high as 20,000 tons. In 1889, 5,341 tons were mined. The average percentage of manganese contained in the shipments of the Jackson Iron Company in 1889 was 8.05. The average analysis of the ore shipped was as follows:

	PER CENT.
Iron	52.950
Manganese	8.050
Silica	8.270
Phosphorus	0.054

In what is known as the Saint Croix district some very interesting developments in connection with manganiferous iron ore have been made in the past, and there are promising indications for the future.

Saint Croix county, Wisconsin, in which these developments have been made, is in the extreme western part of the state, where the boundary thrusts itself out into Minnesota. Manganese seems to exist in three forms; that is, as wad, which is found in pockets from 1 to 5 feet in depth, the ore carrying from 15 to 35 per cent of manganese; as a manganiferous iron ore (limonite), carrying from 0.5 to 15 per cent of manganese, and as a real manganese ore. Analyses of the ore from Saint Croix are as follows:

ANALYSES OF MANGANESE ORES FROM SAINT CROIX, WISCONSIN.

COMPONENT PARTS.	No. 1.	No. 2.
	Per cent.	Per cent.
Silica	11.350	5.200
Iron	2.250	1.000
Manganese	47.031	48.870
Combined water	6.314	6.717
Phosphorus	{ 0.017 } { 0.016 }	{ } { 0.022 }

In view of the fact that all of the mines in Michigan that produce manganese or manganiferous iron ores are operated as iron mines, it is impossible to give any statement as to the number of employés, amount of wages paid, or capital invested in the production of manganese, as these items are all included in the report on the iron-ore production of the mines supplying it, and it is impossible to state what percentage of these items should be charged to manganese and what to iron ore. The only statistics, therefore, that can be given are production and value, and they are as follows:

STATISTICS OF THE PRODUCTION OF MANGANIFEROUS IRON ORE IN LAKE SUPERIOR REGION IN 1889.

Production averaging about 9 per cent manganese (tons)	31,341
Production averaging about 6.74 per cent manganese (tons)	50,018
Total production (tons)	81,359
Total value of ore at mines	\$264,417.00
Average value per ton	3.25

The production of manganiferous iron ore in Lake Superior region since 1886, so far as the same has been ascertained, is as follows:

Production in 1886:	TONS.
Production averaging 2 per cent of manganese	100,000
Production averaging 4 per cent of manganese	157,000
Total	257,000
Production in 1887:	
Production averaging 4 per cent of manganese	200,000
Production averaging 10 per cent of manganese	10,000
Total	210,000
Production in 1888:	
Production averaging 4 per cent of manganese	189,574
Production averaging 11 per cent of manganese	11,562
Total	201,136
Production in 1889:	
Production averaging 6.74 per cent of manganese	50,018
Production averaging 9 per cent and over of manganese	31,341
Total	81,359

MAINE.

In Maine no manganese was produced in 1889. Considerable bog ore was mined at one time in Knox, Oxford, and Hancock counties. In Blue Hill, Hancock county, what is termed a silicate of manganese has been mined at several dates since 1863. The manganese occurs in a vein about 15 feet in width on the summit of Blue Hill. The hill is a mass of contorted gneiss rock, the manganese running through it east-northeast by west-southwest. In 1877 and 1878 some 120 tons were taken out of this mine for use as flux at the furnace of the Katahdin iron works. Some 60 tons were taken out in 1886 for use as flux at the same furnace.

The following are analyses of manganese ore from Blue Hill, Maine:

ANALYSES OF MANGANESE ORE FROM BLUE HILL, MAINE.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Protoxide of iron	14.01	24.91	12
Protoxide of manganese	35.13	29.72	15
Alumina	7.45	3.04	.....
Lime	3.49	5.02	.....
Silica	35.84	35.70	39
Phosphoric acid	1.02	.....	.....

MARYLAND.

Manganese ore was at one time mined to some extent in Maryland from a deposit near Brookeville, in Montgomery county, and also from a deposit on the north side of the Potomac river, opposite Harpers Ferry. No manganese has been produced in this state for a number of years.

MASSACHUSETTS.

Pyrolusite is frequently found in connection with the limonite ores in the western part of Massachusetts, as it is so frequently found in connection with the same ores all through the Appalachian region. It is rarely, if ever, found in sufficient quantities to justify its separation for sale as manganese ore.

MISSOURI.

Considerable quantities both of manganese ores and manganiferous iron ores have been mined in Missouri for use in the Saint Louis furnaces in the manufacture of spiegeleisen. These ores have been derived chiefly if not entirely from what Professor Pumpelly has termed the "porphyritic" region of Pilot Knob and vicinity, and are usually found associated more or less intimately with iron ore. In 1881 some 2,000 tons of this ore were taken from 1 mine in this section, but since that year none has been mined on a commercial scale.

On what has been termed the "Cuthbertson-Buford Hill" in this Pilot Knob region several deposits occur, from which the ore already referred to was chiefly derived. On the Cuthbertson tract masses of float manganese ore, varying greatly in size, are found, and in the hill occurs a bedded deposit of irregular tubular masses of manganese ore bedded in red ochereous clay. The manganese exists in the ore as red sesquioxide, with a probable admixture of binocide. This ore is a true manganese ore, as will be seen from the following analysis:

ANALYSIS OF MANGANESE ORE FROM CUTHBERTSON, MISSOURI. (a)

	PER CENT.
Manganese as protoxide	68.20
Peroxide of iron	3.30
Insoluble siliceous matter	0.44
Metallic manganese	52.47

a Chauvenet and Blair, chemists.

The ore of the Buford bank, adjoining the Cuthbertson tract, is a manganiferous iron ore, but it occurs in a bedded deposit similar to Cuthbertson's manganese ore. An analysis of this by Mr. Chauvenet gave the following results:

ANALYSIS OF MANGANESE ORE FROM BUFORD BANK, MISSOURI.

	PER CENT.
Manganese as protoxide	15.84
Peroxide of iron	68.30
Insoluble matter	8.54
Sulphur	0.02
Phosphoric acid	0.10
Or—	
Metallic manganese	12.32
Metallic iron	47.81
Phosphorus	0.04

A small amount of manganiferous iron ore was taken from Buford mountain some years since for use at the Vulcan steel works at Saint Louis. The ore averaged about 15 per cent manganese. The deposit was some distance from the railroad, and it was not deemed advisable to prosecute mining.

Near Cuthbertson, on Mr. Marble's land, Professor Pumpelly found a manganese deposit, forming an inner stratified layer 3 to 5 inches thick in a decomposed porphyry, showing 51.06 per cent of manganese as protoxide.

Mr. P. N. Moore, an assistant of the geological survey of Missouri, reports the existence in Reynolds county, as one of the members of a series of bedded porphyry rocks, an ore of the black oxide of manganese, occurring in narrow, conchy strings in the porphyry. A very compact, hard specimen of this, so hard that it struck fire with steel, gave Mr. Chauvenet the following analysis:

ANALYSIS OF MANGANESE ORE FROM REYNOLDS COUNTY, MISSOURI.

	PER CENT.
Manganese as protoxide.....	37.04
Manganese as peroxide.....	5.48
Insoluble silica.....	45.55

The 2,000 tons referred to above as being mined in this state in 1881 were from the property of the Arcadia Mining Company, near Arcadia, Missouri. The analysis was as follows:

ANALYSIS OF MANGANESE FROM ARCADIA, MISSOURI. (a)

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	64.98	58.02
Metallic iron.....	2.82	3.35
Phosphorus.....	0.04	0.03
Silica.....	2.82	3.35

a Farrell, chemist.

This ore was used in the furnaces of the Missouri Furnace Company at Saint Louis in such quantities as to give 0.75 per cent of manganese in the iron. The analyses above given were of exceptionally rich specimens of the ore

NEVADA.

A small amount of manganese has been produced in Nevada, near Golconda, on the Central Pacific railroad, in the valley of the Humboldt river, but the expense of getting it to market has been so great that no use has been made of it. A few tons, 13.25, are said to have been shipped a few years ago to San Francisco, but the cost of freight to market was too great to make the venture a commercial success. The deposit is not worked at present.

The ore is a massive, black, glossy oxide of manganese with the following component parts:

ANALYSIS OF MANGANESE ORE FROM GOLCONDA, NEVADA.

	PER CENT.
Manganese protoxide	65.66
Oxygen.....	10.31
Ferric oxide	3.32
Alumina.....	0.34
Cobalt oxide.....	(a)
Lime	3.44
Baryta.....	5.65
Magnesia.....	1.26
Potash.....	0.35
Soda	None.
Water and organic matter.....	4.16
Phosphoric acid	None.
Tungsten acid	2.78
Silica.....	1.70
Total.....	98.97
Manganese	50.85
Iron.....	2.32
Tungsten.....	2.20
Phosphorus.....	None.
Moisture	4.97

a Not determined.

NEW HAMPSHIRE.

Some manganese has been found associated with the iron ores that were worked in this state many years ago, but manganese as a separate ore has never been produced. Some pyrolusite is said to have been found in connection with silicate of manganese in Cheshire county.

NEW JERSEY.

The first spiegeleisen produced in the United States as a commercial product was from the zinc ores of Sussex county, New Jersey. These ores, which may be termed manganiferous zinc ores, are mined primarily for their zinc contents, though they carry a considerable percentage of manganese. The selected Buckwheat ore carries from 26.34 to 28.78 per cent of zinc, and from 12.27 to 13.65 per cent of metallic manganese; the lean Buckwheat, from 21.14 to 21.79 per cent of zinc and from 12.12 to 12.35 per cent of manganese; the Sterling ore, from 18.76 to 23.61 per cent of zinc and 9.46 to 11.13 per cent of manganese; while the Front vein carries 18.41 per cent of zinc and 13.79 per cent of manganese. The analyses of these ores are given in connection with the discussion on the production of spiegeleisen and ferro-manganese on page 329 of this report.

The residuum from working these manganiferous zinc ores for their zinc contains more manganese per ton of residuum than the ore itself, and it is this residuum that is smelted in the blast furnace for spiegeleisen. Analyses of this residuum or clinker, as given in a subsequent part of this report, show from 12.13 to 16.29 per cent of manganese, though it is unusual to find as much as 14.5 per cent in the residuum. The average content is from 9 to 14 per cent.

As the character of these ores and the residuum and its uses are so thoroughly discussed under the head of "Manufacture of spiegeleisen and ferro-manganese", nothing more need be said regarding them at this place.

The total residuum from these ores used in the manufacture of spiegeleisen in 1889 was 43,648 tons, producing 14,124 tons of spiegel.

NORTH CAROLINA.

Reported discoveries of manganese ore in North Carolina are quite frequent. Up to the present time it has not been found in paying quantities. The amounts reported as being mined in this state have been only trial lots. Some of the deposits of North Carolina appear to hold the same relation to the iron ores and to the several mountain ranges as do many of the deposits of Virginia. At Buckhorn iron mine, located in Chatham county, on the borders of Harnett county, sheets of laminated black oxide of manganese from 1 to 2 inches thick occur, while in the lower part of the bed the iron ore is quite manganiferous. An analysis of this lower part is given as follows:

ANALYSIS OF MANGANESE ORE FROM CHATHAM COUNTY, NORTH CAROLINA.

	PER CENT
Oxide of manganese	22.80
Metallic iron	18.41
Phosphorus	0.02
Silica	30.50
Alumina	19.20

It will be seen from this analysis that the ore is a silicate of manganese.

Quite thorough explorations for manganese have been made in the Warm Springs basin. This basin is about 8 miles long and from 1 to 3 miles wide. On its northern end are large beds of limonite, while a continuous belt of manganese ore is found on its western side.

Analyses of this ore are as follows:

AVERAGE COMPOSITION OF MANGANESE ORE FROM THE
WARM SPRINGS BASIN, NORTH CAROLINA.

ANALYSES.	Metallic manganese.	Phos- phorus.
	<i>Per cent.</i>	<i>Per cent.</i>
No. 1	41.710	0.103
No. 2	38.270	0.064
No. 3	42.800	0.187
No. 4	48.010	0.157
No. 5	44.090	0.254
Average	42.976	0.153

Other and more complete analyses of ore from the Warm Springs region, North Carolina, are as follows, No. 1 being by Carnegie Brothers & Co., limited, of Pittsburg, and No. 2 by Dr. Charles W. Dabney, jr.:

ANALYSES OF MANGANESE ORE FROM MADISON COUNTY,
NORTH CAROLINA.

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Silica	10.12	
Iron	2.65	12.49
Manganese	48.93	49.86
Phosphorus	0.17	
Gangue		0.86
Manganese dioxide		78.87
Sesquioxide		17.72

There is a series of beds containing manganese associated with the King mountain schists (slates) of Gaston, Lincoln, and Catawba counties, which are superficially changed to black oxide. One notable locality is near the old forge on Crowder creek. The composition of this ore is as follows:

ANALYSIS OF MANGANESE ORE ASSOCIATED WITH THE KING MOUNTAIN SLATES, NORTH CAROLINA.

	PER CENT.
Silica	40.395
Oxide of iron	12.146
Alumina	9.025
Phosphoric acid	0.030
Sulphuric acid	0.024
Sulphide of iron	0.218
Protosessquioxide of manganese	29.780
Lime and magnesia	(a)
Metallic iron	8.602
Metallic manganese	21.450
Phosphorus	0.013
Sulphur	0.112

a Not determined.

The only mine worked in this state, so far as has been ascertained, is located in the northwestern corner of Madison county. 3 car loads of ore were shipped in 1888, 2 to Liverpool and 1 to Pittsburg. The ore consists of pyrolusite and a black oxide containing from 48 to 50 per cent of metallic iron. It exists both in lumps and in a soft pulverulent variety, very pure and much crystallized. In 1889 47 tons were mined in this state from the Warm Springs district. 2 car loads, containing 30 tons, were shipped to Pittsburg and 1 to Johnstown, Pennsylvania. The ore, however, contained too much phosphorus to permit of its use in the manufacture of ferro-manganese and spiegeleisen.

The statistics of the production of manganese in North Carolina in the census year are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN NORTH CAROLINA IN 1889.

Total production (tons)	47
Total value	\$470
Value per ton	\$10
Total number of employes	2
Total wages paid	\$160
Total capital used in developing	\$250

The production of manganese in North Carolina, so far as the same has been ascertained, from 1886 to 1889, inclusive, is as follows:

PRODUCTION OF MANGANESE IN NORTH CAROLINA FROM 1886 TO 1889, INCLUSIVE.

	TONS.
1886	15
1887	14
1888	50
1889	47

PENNSYLVANIA.

Manganese ore is of quite frequent occurrence in Pennsylvania, although but few deposits have yet been discovered that have been worked. Perhaps the largest mines worked in the state were 2 at Ironton, in Lehigh county, in connection with iron ore. In the iron mines of the Ironton company manganese ore has been twice met

with in local beds in considerable quantities. One deposit overlaid a portion of the brown hematite, and the other was just above the limestone under the brown hematite, and separated from it by a red clay. Several hundred tons were taken from these beds. The following analyses were made by Mr. A. S. McCreath (No. 1) and Mr. Henry Pemberton, jr. (No. 2):

ANALYSES OF MANGANESE ORES FROM LEHIGH COUNTY, PENNSYLVANIA.

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	52.63	56.58
Metallic iron.....	2.56	
Phosphorus.....	0.06	Trace.
Sulphur.....	Trace.	

Another sample from the Ironton company's mine gave:

ANALYSIS OF MANGANESE ORE FROM THE IRONTON COMPANY'S MINE.

	PER CENT.
Metallic manganese.....	17.648
Metallic iron.....	26.400
Phosphorus.....	0.095
Sulphur.....	0.010
Insoluble residue.....	21.860

In this district the brown hematites often contain some manganese, 0.5 per cent to 3 per cent not being uncommon.

In addition to its occurrence in these Lehigh mines, it has been noticed in many of the mines of Northampton and Berks counties, at places in Blair, Centre, and Huntingdon counties, and at various localities on Broad mountain. In the No. XI red shale of the Ground Hog valley, in Broad Top, there is a lead of manganese ore 2 to 3 feet thick, carrying 50 per cent metallic manganese and 0.4 per cent phosphorus.

At an iron-ore bank in York county, near Myers Mills, leased by the Ashland Iron Company, of Maryland, is a manganiferous iron ore (limonite) that gives the following analysis (McCreath):

ANALYSIS OF MANGANIFEROUS IRON ORE FROM YORK COUNTY, PENNSYLVANIA.

	PER CENT.
Metallic manganese.....	15.934
Metallic iron.....	32.400
Phosphorus.....	0.651
Sulphur.....	0.027

Near the close of 1889 a deposit that promises to be of some importance was discovered in Caernarvon township, Berks county, by Dr. D. Heber Plank. Dr. Plank states that manganiferous ores may be found all along the western or mesozoic border of the Morgantown or upper Conestoga valley in the little basins or valleys running down from the shale and conglomerate sandstone belt and where drainage is into the Conestoga creek, and that this outcrop of manganese has been observed for at least 5 or 6 miles, commencing at a point 1.5 miles northeast of Joanna station, Wilmington and Northern railroad, thence west-northwest through northern Caernarvon, southern Robeson, and southern Brecknock townships. The farmers of the district call it black sandstone. Dr. Koenig, of the University of Pennsylvania, who made an examination of this district, states that the present surface is chiefly composed of a conglomeratic sandstone impregnated with psilomelane or hard manganese ore, this latter occurring in dendrites in little nests and larger nodules, and having the following composition:

ANALYSIS OF MANGANESE ORE FROM BERKS COUNTY, PENNSYLVANIA.

	PER CENT.
Manganimanganic oxide.....	22.900
Barium oxide.....	3.020
Potassium oxide.....	1.250
Phosphoric oxide.....	0.206
Silica.....	58.280
Iron oxide and alumina.....	7.120
Cobalt oxide.....	Trace.
Water.....	7.620
Total.....	100.396
Metallic manganese.....	16.500
Phosphorus.....	0.144

No manganese was produced in Pennsylvania in 1889.

As stated above, few of these deposits are of sufficient extent to justify mining for manganese. Others are too high in phosphorus for steel purposes or too low in manganese to justify shipping abroad for chemical manufacture.

In this state there are 3 blast furnaces making ferro-manganese and spiegel iron regularly, that of the Lehigh Zinc and Iron Company, at Bethlehem, using zinc residuum; one of the furnaces of the Cambria Iron Company, and furnace "A" of the Edgar Thompson steel works at Pittsburg, both of the latter using manganese and manganiiferous iron ores,

RHODE ISLAND.

Bog manganese ore and oxides of manganese have been found in Rhode Island, but never in sufficient quantities to justify mining.

SOUTH CAROLINA.

Very little manganese has been produced in this state, though no doubt deposits exist here as they do in North Carolina. Indeed, what is said in a general way as to North Carolina deposits will apply equally well to those of South Carolina, except that smaller quantities have been found in the latter state. The only deposit that appears to have been worked to any extent is that of the Manganese Mining Company, which operated in 1885 and 1886 on the Dorn lands, near McCormick. It is reported that some 300 tons had been mined up to the close of 1886. The following is an analysis of this ore:

ANALYSIS OF MANGANESE ORE FROM DORN COUNTY, SOUTH CAROLINA.

	PER CENT.
Peroxide of manganese	75.28
Protoxide of manganese	3.73
Oxide of iron	14.56
Alumina	2.63
Phosphoric acid	0.24
Silica	3.54
Sulphur	0.02
Total	100.00

The metallic manganese in the above ore is 50.34 per cent, and phosphorus 0.11 per cent. All of the manganese produced in South Carolina was from this neighborhood and from 2 workings. An analysis of this ore is as follows:

ANALYSIS OF MANGANESE ORE FROM MCCORMICK, SOUTH CAROLINA.

	PER CENT.
Manganese	45.018
Iron	2.750
Silica	8.100
Phosphorus	0.085
Moisture	9.000

The statistics of the production of manganese in South Carolina in 1889 are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN SOUTH CAROLINA IN 1889.

Total production (tons)	124
Total value	\$744
Value per ton	\$6
Total number of employes	6
Total wages paid	\$400
Total capital invested in lands, etc., and employed in business	\$5,000
Capital invested in lands	\$2,500
Capital invested in buildings and fixtures	750
Capital invested in tools, implements, live stock, machinery, and supplies on hand	250
Capital invested in other items, including cash	1,500

The total production of manganese ore in South Carolina, so far as the same has been ascertained, is as follows:

TOTAL PRODUCTION OF MANGANESE ORE IN SOUTH CAROLINA.

	TONS.
1885 and 1886	300
1887	45
1888	50
1889	124

TENNESSEE.

So far as has been learned, the first manganese produced in the United States was in 1837, near Whitfield, in Hickman county, Tennessee. It was for use in coloring earthenware, and it has been used for this purpose quite continuously ever since. The production, however, has been but a few hundred pounds each year.

Lumps of manganese oxides are frequently found in the iron-ore regions of Tennessee. They are isolated pieces, however, the ore rarely, if ever, occurring in beds or deposits worthy of any special notice. Hickman county is in the western iron region of the state, in which iron was extensively made before the war, and in which some furnaces are now at work. The ore in this region is limonite, and it is with this and with the cherty gravel scattered over the surface of the country that the isolated lumps of manganese ores are found.

Small masses of manganese oxide more or less pure are often met with on nearly all the low, cherty regions of the valley of east Tennessee. They also occur, as in Greene county, with iron ore at intervals, at the foot of the extreme eastern mountains (the Unakas) all the way from Virginia to Georgia. Manganese ores are also found all down the Chilhowee mountain range, but in pockets and too far from any railroad to justify their transportation.

The production of manganese in Tennessee in 1889 was but 30 tons. The statistics of this production are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN TENNESSEE IN 1889.

Total production (tons)	30
Total value	\$120
Value per ton	\$4
Total number of employes	3
Total wages paid	\$70
Total capital	\$100

The capital employed was simply that necessary in putting down experimental shafts.

The total production of manganese, so far as the same has been ascertained, is shown in the following table. This is exclusive of the small amount worked each year since 1837 in Hickman county for use in coloring earthenware.

TOTAL PRODUCTION OF MANGANESE ORE IN TENNESSEE.

	TONS.
1886	50
1887 .....	..
1888	16
1889	30

VERMONT.

According to Hitchcock's Geology of Vermont, published in 1861, considerable manganese ore had been shipped from Brandon and Chittenden, in that state, to England. Dr. Prime, of Brandon, informs Dr. Penrose, of the geological survey of Arkansas, that deposits were worked in the neighborhood of Brandon about 75 years ago, but that the manganese which was found in connection with the iron ore was avoided, as it was thought to be injurious to the iron, and that no manganese was produced until about 1859.

The deposits of any importance that have been discovered in this state are at South Wallingford and Brandon, in the Otter Creek valley, and at Chittenden. The most important developments, however, have been at Brandon and South Wallingford. The South Wallingford mines are located at South Wallingford, Rutland county, at the foot of the Green Mountain range, half a mile east of the Bennington and Rutland railroad.

According to a statement furnished the writer by Mr. Bradley and published in the volume of Mineral Resources of the United States, 1888, these deposits were worked to some extent some 60 or 70 years ago for their iron ore. The quantity of manganese they carried, however, was such, in the condition of iron smelting at that time, that the persons mining were not able to utilize the ore, and it went to waste. Some 40 years ago Messrs. Lapham & Vail mined the ore and worked it in a forge near by, producing sleigh shoes, bars, butcher knives, etc. The mine was abandoned because the miners believed they had won all the ore. It is now known, however, that they had only worked on the top of the deposit. They tried to sink a shaft to reach ore which they supposed existed below, but they struck a large vein of water and abandoned the operation. Some 15 years since a few hundred tons of ore were mined, and again the mine was abandoned. Some 2 years since Messrs. Bradley & Lyons commenced operations. They found it necessary to go deeper into the mine, and drove in a tunnel at the foot of the mountain 517 feet into a siliceous limestone formation. After drifting through this for 300 feet they encountered ocher for 100 feet or more, after which they turned north, encountering a large body of excellent manganese ore. The ore is found between a wall of siliceous limestone on the west and broken massive quartz on the east, the walls being 150 feet apart. Beneath the drift were found ochers, clays, kaolin, and manganese ore, the latter lying near the quartz, with a seam of black ocher between the ore and wall. The deposit dips about 40° to the east; the trend of the vein is south. Next to the manganese ore on the west is a shell of brown ore. In the mine all grades of ore, from the ordinary brown hematite to the highest grade of manganese, are found. Much of the hematite ore is of a beautiful stalactitic formation. Cubical and needle crystals are also found. One of the strange features of this mine is this ore channel, as the proprietors term it, between the two walls before noted.

Analyses of this ore are as follows:

ANALYSES OF SHIPMENTS OF MANGANESE FROM SOUTH WALLINGFORD, VERMONT,
FOR THE WINTER OF 1887-1888, SHIPPED AS MINED, UNWASHED.

Silica.	Iron.	Manganese.	Phosphorus.
<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
a9.520	33.383	29.141	0.088
a10.000	26.104	26.182	0.064
a7.480	32.128	29.602	0.073
b12.500	14.650	34.393	11.151

a This ore was taken from only 30 to 50 feet below surface.

b Analysis of shipments for winter 1888-1889, ores at 50 to 60 feet deeper than specified above. Samples for analysis were from car loads of unwashed ore from vein some 100 feet south.

ANALYSES OF WASHED ORE FROM VEIN 500 FEET NORTH OF ORE SPECIFIED IN
ABOVE TABLE, AT 27 FEET FROM SURFACE, MADE JUNE, 1888.

Silica.	Iron.(a)	Manganese.(b)	Phosphorus.
<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
9.230	7.180	44.107	Not given.
3.100	25.000	35.000	0.061
7.900	4.970	48.778	0.111

a Samples from face of drift, January 5, 1889, as near as could average; selection, ore 40 to 50 feet under that given in first table.

b From vein 100 feet south of above, average as near as possible, December 3, 1888.

The massive manganese ore in this deposit occurs in the form of geodes or "pot ore", which are sometimes filled with water and locally known by the miners as "water holes". Occasionally well-formed stalactites of massive black ore are found in the interiors of the cavities.

This deposit was worked by Carnegie Brothers & Co., limited, in 1889 and part of 1890, mining being discontinued by them before the end of the latter year.

The Brandon mine is in the town of Brandon, on the Central Vermont railroad, in Rutland county. Manganese ores were first worked here in 1860, and have been mined at intervals since. Explorations were made at this mine in 1889 and 1890 by Messrs. Carnegie Brothers & Co., limited, but were abandoned in 1890, and the old pits have caved in.

The statistics of the production of manganese in Vermont in 1889 are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN VERMONT IN 1889.

Total production (tons)	1,576
Total value	\$8,668
Value per ton	\$5.50
Total number of employes	25
Total wages paid	\$3,510
Total capital invested and employed in business	\$7,250
Capital invested in buildings and fixtures	\$1,250
Capital invested in tools, implements, live stock, machinery, and supplies on hand	1,000
Capital invested in other items, including cash	5,000

The production of manganese in Vermont in 1888 and 1889, the 2 years concerning which there is a report, was as follows:

PRODUCTION OF MANGANESE IN VERMONT IN 1888 AND 1889.

	TONS.
1888	1,000
1889	1,576

VIRGINIA.

The production of manganese in Virginia in 1889 was 14,616 tons, which would grade as manganese ore proper. The statistics of this production are as follows:

STATISTICS OF THE PRODUCTION OF MANGANESE IN VIRGINIA IN 1889.

Total production (tons)	14,616
Total value	\$156,257
Value per ton	\$10.69
Total number of employes	171
Total wages paid	\$65,939
Total capital invested in lands, etc., and employed in business	\$711,000
Capital invested in lands	\$350,000
Capital invested in buildings and fixtures	25,000
Capital invested in tools, implements, live stock, machinery, and supplies on hand	175,000
Capital invested in other items, including cash	161,000

The production of manganese so far as has been ascertained, from 1880 to 1889, inclusive, was as follows:

PRODUCTION OF MANGANESE IN VIRGINIA FROM 1880 TO 1889, INCLUSIVE.

	TONS.
1880	3,661
1881	3,295
1882	2,982
1883	5,355
1884	8,980
1885	18,745
1886	20,567
1887	19,835
1888	17,646
1889	14,616

It will thus be seen that there has been a gradual decrease since 1886, the year of the greatest production, when 20,567 tons were mined. The total production in Virginia in 1889 was not equal to the production of the Crimora mines in 1885, 1886, 1887, and 1888.

The production of the Crimora mines and the adjoining mine, the Old Dominion, which were worked as one, from 1886 to 1889, was as follows:

PRODUCT OF THE CRIMORA MINES, VIRGINIA.

	TONS.
Prior to 1869	5,684
May, 1869, to February, 1876	280
February, 1876, to December, 1878	2,326
December, 1878, to December, 1879	1,602
1880	2,963
1881	2,495
1882	1,652
1883	5,185
1884	8,804
1885	18,212
1886	19,382
1887	19,100
1888	16,100
1889	12,974

So far as explorations have been made, manganese ores have been found over a much greater extent of territory in Virginia than in any other of the United States. It is uncertain what future developments may prove, but Virginia has more known deposits of this mineral. They are spread over a greater extent of territory, more localities have been worked, and more manganese has been raised, and yet there were but 2 localities in this state, Crimora and Houston mines, from which any material amounts of manganese were produced in 1889. A small amount of a very high grade of pyrolusite for use in glass making and in the manufacture of bromine was shipped from a third mine, the Leets or Lemer mine, at Mount Athos. These three are the only regular producing mines in the state, and at present the Houston and Crimora are falling off in production.

In Virginia, as elsewhere, deposits of manganese almost invariably accompany those of iron. Where iron ores are abundant, more or less of manganese may be confidently looked for. At least 8 groups of the geological formations in Virginia are iron bearing; each of these contains more or less manganese. These iron ores are found in belts or bands, generally extending across the state in a northeast and southwest direction, following the strike of the outcrops of the rocks as a rule.

Many of the deposits opened in this state exhibit in a marked degree the uncertainties and risks of manganese mining, as well as the misleading character of "indications". Deposits that have promised remarkable results as

well as large returns to their owners have proved in many cases to be pockets of small extent, producing at most but a few hundred tons of ore before exhaustion, and baffling all attempts to discover additional ore in their vicinity. In other deposits the ore will prove high in phosphorus or low in manganese, or so irregular in its content of mineral as to make selection difficult or uncertain and to forbid giving the guaranty of richness, and for some uses of the purity, which purchasers require. For obvious reasons, therefore, it has not been possible in every case to ascertain the exact facts as to the character or the present condition of the deposits discussed. The statements made must be regarded as giving the best information available. They are made "on authority", and are in but very few cases the results of personal examination.

In discussing the manganese deposits of Virginia it will be more convenient to arrange them in accordance with the natural divisions of the state. These divisions are: (1) Tidewater; (2) Midland; (3) Piedmont; (4) Blue Ridge; (5) Valley; (6) Appalachia; (7) Transappalachia.

Some manganese has been found in pockets of small extent in the Tidewater sections of Virginia. One deposit near City Point yielded some hundreds of tons of ore before it was exhausted, and it is reported that others have been worked. No deposits of such extent as that at Crimora can be expected in this region, though it is probable that small pockets will be found in connection with the beds of iron ore that outcrop in the bluffs along the banks of the rivers. The age of these deposits is much later than that of those found resting on the Potsdam in the Valley district, the iron ore with which it is associated being found in the tertiary, chiefly in the Miocene.

In the Midland district of Virginia deposits of manganese become more abundant, this division, with the Valley, furnishing practically all the manganese mined in the state. The ore that has been mined is found chiefly in Campbell, Nelson, and Pittsylvania counties, though there are deposits in Spottsylvania, Louisa, Appomattox, and perhaps other counties. The deposits are found in the extreme western part of the section, well up to the base of the mountains that form the dividing line between this and Piedmont; indeed, it is possible that some of these deposits should be classed in Piedmont, but as they are all situated on the same belt as Campbell county they are classed in Midland.

The Mount Athos mine, which probably produces the highest grade of manganese mined in the United States, is in Campbell county, just across the line from Appomattox county, near Mount Athos station, on the Norfolk and Western railroad, just where the James river turns to the north. It is one of the few deposits on the right bank of the James. This mine is sometimes known as the Leets mine.

The manganese is found in pockets associated with iron ore, and also as button ore in a dark-colored micaceous schist, 8 feet thick, holding some 40 per cent of nodules, varying in size from a bean to that of an oyster. Analyses of this ore are as below:

ANALYSES OF MOUNT ATHOS, VIRGINIA. MANGANESE ORES.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	43.580	45.870	44.180
Metallic iron.....	5.240	5.340	6.640
Phosphorus.....	0.316	0.257	0.274
Silica.....	7.150	7.770	7.790

Some of the ore is much better than these analyses, showing 48 to 50 per cent and even more of metallic manganese. That selected for use in glass making is even higher than this.

Some manganese has been mined at the Bishop mine, Lynch station, Campbell county, which seems to be a continuation of the Mount Athos mine, and also at Leesville, in the same locality.

In Pittsylvania county, southwest of the Mount Athos deposit, a mangiferous iron ore with the following analyses has been found:

ANALYSES OF MANGANIFEROUS IRON ORE FROM PITTSYLVANIA COUNTY, VIRGINIA.

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	24.780	27.860
Metallic iron.....	23.860	28.140
Phosphorus.....	0.302	0.347
Silica.....	7.020	4.320

The deposit is but a quarter of a mile distant from the Virginia Midland railroad.

In Nelson county several deposits of manganese have been worked quite extensively in past years, though no ore is now mined. These deposits are found in the ore belt of the James river, already described, the belt running nearly parallel to the river and about 2 miles from the left or northwestern bank. The manganese shows generally

in small quantities on the surface, the deposit widening as it goes down. The manganese is found in pockets, and usually in clay.

From what is known as the Cabell mine, 2 miles from Warminster depot, on the Richmond and Alleghany railroad, some 5,000 tons of manganese were taken in 1868 and 1869 by Mr. James E. Mills, who was employed by a Newcastle (England) firm, and shipped to Newcastle-on-Tyne, and who probably made the first systematic search for manganese in the United States, unless Mr. Sibert's mining in the valley of Virginia may be termed systematic. The mine has not been worked since 1871. An analysis of the ore showed 82.25 per cent of manganese peroxide.

Two other analyses gave the following:

ANALYSES OF MANGANESE ORES FROM CABELL MINE, VIRGINIA.

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese.....	44.300	43.020
Metallic iron.....	3.670	4.240
Phosphorus.....	0.243	0.182
Silica.....	17.450	18.510

About half a mile southwest of the Cabell mine is a deposit known as the Bugley mine, which was worked about the same time and yielded about 2,000 tons of ore.

At Midway Mills is a deposit, on the land of Mr. G. F. Simpson, which was worked in 1882 and yielded some 1,200 tons of first-class ore. The mine was worked by shaft to the depth of 165 feet, when it was drowned out. The ore above the water line is said to have shown some 70 per cent oxide, but below the line it was much richer, 80 to 85 per cent. The entire product was marketed in Liverpool.

At the Davis mine, in Nelson county, an ore giving from a picked specimen the following analysis was at one time mined, though operations are now suspended:

ANALYSIS OF MANGANESE ORE FROM NELSON COUNTY, VIRGINIA.

	PER CENT.
Manganese binoxide	90.42
Iron sesquioxide	2.24
Alumina	1.13
Lime	1.22
Magnesia	2.28
Silica.....	1.12
Phosphoric acid	0.43
Water	1.25
Metallic manganese.....	57.16
Metallic iron	1.56
Phosphorus.....	0.19

Some 1,000 tons have been taken from this mine. Deposits are also reported in Appomattox and Amherst counties.

No details have been obtained concerning the manganese ores of the Piedmont and Blue Ridge districts. The deposits are small and of no commercial value.

The chief sources of the manganese produced in this state and in the country are the mines of the valley of Virginia, or, as it is sometimes called, the Shenandoah valley. In this valley are located the Crimora mines, that have produced as much ore as the entire country besides, and the Houston mines. The manganiferous belt lies along the western base of the Blue Ridge, on the eastern side of the valley. It is asserted that this belt extends 300 miles in the state, and that workable beds of manganese ore have been found in every one of the 12 valley counties that abut on the western foot of the Blue Ridge.

It is along this belt that the remarkable body of iron ore accompanying the potsdam or No. I formation of Rogers is found, and with this iron the manganese ores are associated. Indeed, it is in the clays formed by the decomposition of the ferriferous shales of the potsdam that the ore is usually found imbedded. An exception to this is noted by Professor William M. Fontaine, in his "Notes on the mineral resources at certain localities in the western part of the Blue Ridge", as occurring on the lands of Joshua Robertson, some 5 miles from Waynesboro. The ore at this point, which is psilomelane, occurs in the primordial formation in a fissure in a cracked and crushed band of the upper gray shales and flags, and has impregnated the walls, which are kaolin flags. Some 100 tons were taken from this locality in 1857 by a Mr. Sibert. Professor Fontaine is of the opinion that the origin of this manganese is similar to that of the iron ore occupying a similar geological position, viz, deposition in disturbed beds from solution in water.

Manganese mining began in this state and district as early as 1859, a Mr. Sibert having made thorough explorations through the whole extent of the valley, opened up quite a number of deposits, and shipped the product to England for chemical purposes. Mr. James E. Mills, who was employed by a Newcastle (England) firm, also did some mining in this district, though his chief work in production was done at the Cabell mine, in the Midland district.

The most important deposits of manganese and manganiferous iron ores in the valley of Virginia and in the state in production are those at Shenandoah, in Page county, at Crimora, including the Old Dominion mine, in Augusta county, and the Houston mines, in Botetourt county. There are other deposits which will be referred to, but these 3 are the notable ones. As the Crimora mines are described in the discussion on the "Origin and occurrence of manganese", in another part of this report, it will not be necessary to repeat what was there said.

Considerable quantities of manganese and manganiferous iron ores have been taken from the iron-ore mines at Shenandoah, formerly called Shenandoah iron works and mines, in Page county. The average analysis of the shipments of 1885 was as follows:

ANALYSIS OF MANGANIFEROUS ORES FROM PAGE COUNTY, VIRGINIA.

	PER CENT.
Metallic manganese	28.00
Metallic iron	17.00
Phosphorus	0.15

Ore of a much higher grade has been found there, and considerable ore mined and in sight, but none is being sold at present. The ore is found in a wash or drift deposit associated with brown hematite. The deposit is quite irregular and uncertain. This range of ore lies along the eastern foot of the Blue Ridge, and evidently contributed to the Crimora basin, which is in this range.

From a deposit on what is known as the Garrison tract, the top of which is a fine ore, but which becomes coarser and harder as it goes down, Mr. A. S. McCreath took samples which gave the following analyses:

ANALYSES OF MANGANESE ORES FROM THE GARRISON TRACT, VIRGINIA.

COMPONENT PARTS.	Fine ore.	Lump ore.
	Per cent.	Per cent.
Metallic manganese	52.681	53.656
Metallic iron	2.325	1.537
Phosphorus	0.324	0.327
Silica	27.950	1.955

A manganiferous iron ore is found in the Kimball bank, lying 3 miles east from Shenandoah. This bank consists of 2 openings, the Atwood and Bolan, the Atwood carrying the larger proportion of manganese. A sample of these ores mixed (two-thirds Atwood and one-third Bolan) showed the following analyses:

ANALYSIS OF MANGANESE ORE FROM KIMBALL BANK.

	PER CENT.
Metallic iron	40.875
Metallic manganese	7.349
Phosphorus	0.084
Siliceous matter	15.440

Another analysis of the ore by Bowron gives—

	PER CENT.
Sesquioxide of iron	70.00
Manganese oxide	13.31
Silica	4.73
Alumina	0.86
Water	11.02
Phosphorus	Mere trace.

The Lyndhurst deposit was opened by Mr. Sibert in 1859. He sunk a shaft, striking the ore deposit at the depth of 45 feet. From the bottom of the shaft a drift was driven some 20 feet. Upward of 250 tons of ore were taken from the shaft and drift and shipped to London. Analyses of the ore recently taken from this shaft are as follows (J. Blodgett Britton, chemist):

ANALYSES OF MANGANESE ORE FROM HEISERMAN'S FARM, AUGUSTA COUNTY, VIRGINIA.

COMPONENT PARTS.	No. 1.	No. 2.
	Per cent.	Per cent.
Peroxide of manganese	93.06	86.77
Peroxide of iron	Trace.	2.98
Silica	0.18	3.98
Alumina	0.91	2.81
Baryta	2.81	0.31
Water (total)	2.75	2.93
Lime		Trace.
Not determined and loss	0.29	0.22
Total	100.00	100.00
Available peroxide	92.54	86.62

The old shaft was destroyed and filled up by a flood, a very common occurrence apparently in this section. The new shaft is located above the flood level. Near this is a deposit showing manganese in process of formation into lumps.

The Kennedy tract, a well-known manganese deposit, is 3 miles from Stuarts Draft station, on the Shenandoah Valley railroad. This is another of the deposits opened up by Mr. Sibert. It takes its name from the old Kennedy furnace, built early in the present century, and adjoins the lands of the more recent Mount Torrey furnace. Mr. Sibert is reported to have mined some 100 tons of the ore in 1859. In 1872 a Mr. Armstead dug some pits, searching for iron ore, and is reported to have discovered at a depth of 20 feet a bed of psilomelane. Ore taken from this opening shows from 30.52 to 43.30 per cent of manganese.

A complete analysis is as follows:

ANALYSIS OF MANGANESE ORE FROM KENNEDY TRACT.

	PER CENT.
Metallic manganese	43.300
Metallic iron	3.880
Sulphur	0.083
Phosphorus	0.052
Barium	6.930

The ores occur both as manganese ores and as manganiferous iron ores. At one point it is in bands and films one-fourth of an inch in thickness, the ore being nodular in form and inclosed in clay from the ferriferous shales.

At Blue bank, at the Fauber mines, at the Newton mine bank, at the Kelly bank, and several banks on the Big Mary creek, all in the neighborhood of the old Cotopaxi and Vesuvius furnaces, which have been abandoned for some years, manganese and manganiferous iron ores have been found and mined to some extent. These deposits are all near the line of the Shenandoah Valley railroad and near the line separating Augusta and Rockbridge counties. The Blue bank was opened to supply the Cotopaxi furnace, but it had too much manganese in it to be used as an iron ore, and the working was abandoned. The Fauber mines were opened by Mr. Sibert, who took from them some 75 tons of manganese, it is said. The deposit is psilomelane in nodular masses and lumps in clay. The Newton mine bank is in a steep ridge near the headwaters of the south James river. Sometimes the ore from this mine is a quite pure oxide of manganese, and again only a manganiferous iron ore. The deposit is quite large, a section showing one of the two veins to be 36 feet wide, composed of alternate deposits of hematites, mixed iron and manganese, and manganiferous iron ore. An analysis of a sample of the ore, 143 pieces taken from along the face of the open cut, made by Mr. McCreath, shows:

ANALYSIS OF MANGANESE ORE FROM THE NEWTON MINE BANK.

	PER CENT.
Metallic iron	41.125
Metallic manganese	8.221
Phosphorus	0.265
Siliceous matter	14.830

The Kelly bank is part of the property of the old Vesuvius furnace, and is situated in Rockbridge county. Both iron ores and manganiferous ores are found, the latter lying nearer the potsdam than the former. Much of the ore consists of iron and manganese mixed, the manganese forming layers and films in the iron.

On Big Mary creek manganese has been found at several openings, and surface indications of other deposits are abundant. Here the same conditions exist as at the Kelly bank, some of the manganese being quite pure and some mixed with iron. The richest manganese shows some 47 per cent of the metal to 6 per cent of iron.

The Houston mines are near a station of the same name on the Shenandoah Valley railroad, in Botetourt county. Some of the ore mined here exceeds 44.25 per cent of manganese, but the average is less than this. A large washing and separating plant has been erected at these mines and very extensive and expensive developments undertaken. The ore occurs in pockets next to iron ore, and examination indicates that the deposit is a large one. About two-thirds of the ore is lump, the rest is quite fine. A selection of 115 pieces to represent the iron ore and 68 pieces to represent the manganese gave Mr. McCreath, upon analysis, the following results:

ANALYSES.

COMPONENT PARTS.	Iron ore.	Manga- nese ore.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic manganese	7.277	44.312
Metallic iron	47.150	12.325
Phosphorus	0.061	0.101
Siliceous matter	8.030	5.470

ANALYSIS OF A SAMPLE OF SELECTED ORE.

	PER CENT.
Metallic manganese	59.870
Metallic iron	0.500
Phosphorus	0.049
Silica	2.300

AVERAGE ANALYSIS OF THE MONTHLY SHIPMENTS FOR 1884 AND 1885.

	PER CENT.
Metallic manganese	39.000
Metallic iron	12.000

The highest monthly average was 45 per cent metallic manganese; lowest, 31 per cent; phosphorus, about 0.07 per cent.

The manganese deposits at this mine lie well up on the west slope of the Blue Ridge range. No. 4 opening is situated on the northwest slope, and just at the foot of a branch ridge separated by a narrow valley, not over 50 feet wide, from another ridge, which lies to the west, and parallel with the ridge in which No. 4 is found. This No. 4 opening is about 1,250 feet above tide water at Richmond, 400 feet above the drainage level of the surrounding country. The deposits of manganese appear from end to end of the tract, which is worked for two-thirds of a mile in length. The ore line runs northeast to southwest, 35 north of east. The manganese occurs in pockets, usually in a tough yellow clay, sometimes next to a fine red sand. Occasionally nests or pockets of the purest manganese are found, yielding 100 to 150 tons of ore in lumps the size of an egg and smaller, and so clean as to require no washing.

At No. 4 opening the principal pocket of manganese lies just above and against the potsdam sandstone, which is here massive and hard. Much of this sandstone, when blasted and shattered, shows very beautiful specimens of pure manganese adhering most tenaciously to the stone. The slates or shales are found to the northwest of the ore line and at the base of the foothills of the Blue Ridge, half a mile from the clays that carry the ore deposits. Adjacent to these the limestone stretches away to the northwest.

Southward from the Houston mines, in the same range, Mr. J. T. Chapman has a deposit of manganese which gave the following:

ANALYSIS OF MANGANESE ORE FROM THE CHAPMAN DEPOSIT, BOTETOURT COUNTY, VIRGINIA.

	PER CENT.
Metallic manganese	45.800
Metallic iron	3.060
Phosphorus	0.164

In Smyth county, on the south fork of the Holston river, in Rye valley, the ore shows at times considerable manganese. Mr. McCreath's analysis of a sample of 133 pieces gave:

ANALYSIS OF MANGANESE ORE FROM THE RAZOR BANK, SMYTH COUNTY, VIRGINIA.

	PER CENT.
Metallic manganese	10.181
Metallic iron	40.100
Phosphorus	0.536
Siliceous matter	10.520

Some 6 miles from Seven Mile Ford station, on the Norfolk and Western railroad, on what is locally known as Chestnut ridge, several openings have been made, showing a rich grade of manganese ore, from which some ore has been taken for trial.

Near Marion, Smyth county, on the east flank of Glade mountain, is a large deposit of manganese, associated with a good brown hematite, which is found in large masses in this region. The deposit has been traced for 8 miles along the outcrop. Large boulders of the manganese are found, some weighing over half a ton.

The following analysis shows the character of the ore:

ANALYSIS OF MANGANESE ORE FROM NEAR MARION, SMYTH COUNTY, VIRGINIA.

	PER CENT.
Metallic manganese	9.910
Metallic iron	45.320
Phosphorus	0.086
Silica	1.760

Some of the manganese ores in Pulaski and Wythe counties are found in the oriskany rocks, the lower member of the devonian, as the potsdam, in connection with which so much manganese is found in this valley, is the lower member of the silurian. The oriskany ores in this section are usually of a much higher grade than the ores of the

potsdam in the same region. The ores are at times brown hematites of a high grade, at others manganese, and at still others nothing but a ferruginous sandstone.

In that portion of Virginia known as Appalachia, which includes the broken mountainous country between the Valley district and West Virginia, quite a number of deposits of manganese ore, some quite high in manganese and of a good quality, are known to exist. Most of these are so situated with reference to transportation routes, however, that they are not available at present.

The manganese ores in this portion of Virginia are, as a rule, of a later geological age than those of the Valley district. The Valley ores are usually found in connection with the Potsdam No. I of Rogers' survey. Those of the Appalachia are found in the Hudson River No. III, the Clinton No. V, and especially in the Oriskany No. VII. In all cases the manganese is associated with iron ores, usually brown hematites, sometimes as a manganiferous portion of an iron ore, at others as a manganese ore. Little or no ore has been mined in this district, though at places the indications for large deposits are favorable. In the southwest corner of Frederick county is a deposit of manganese, known as the Paddy Mills manganese mine, which has produced some manganese in past years. The mine is a conical shaped hill, covering about a square mile, and rising to a height of some 150 feet above the drainage level of the surrounding country. The ore is found in connection with the limestone and imbedded in the strata. The deposit is somewhat unreliable, being cut off by the limestone. The ore is chiefly soft pyrolusite; part of it, however, is hard, running about 50 per cent metallic manganese, 4 per cent iron, and from 0.09 to 0.10 per cent of phosphorus. There have been removed from this mine some 2,000 tons of ore, mostly before the war, and by very imperfect methods of mining. No shaft has gone below 50 feet, so that it is not known how large the deposit is. Should it extend downward considerable ore might be found. The ore requires washing, for which there is plenty of water.

At Van Buren furnace, in Shenandoah county, in connection with the iron ores a valuable and extensive deposit of manganese is found. This was at one time worked extensively, very large amounts being shipped before the war, but no mining has been done for 12 years, owing to the lack of transportation facilities, there being no railroad station nearer than Woodstock, 9 miles distant. The ore occurs in pockets, but they seem to be continuous, and can be traced on the surface for more than 3 miles. The washed ore analyzes upward of 70 per cent oxide. In a description of the Van Buren furnace property, on which this deposit is located, Major Jed. Hotchkiss makes the following statement regarding manganese:

Manganese has been mined in considerable quantities from the mine located at the western end of Cupola mountain, where, as is very often the case in Virginia, it accompanies the outcrop of No. VII (Oriskany), the backbone of that mountain. It outcrops also in the broken hills that prolong Cupola to the southwest; it also shows in places along the iron-ore outcrops of Tea, Little North, and the eastern slope of Paddy mountains, where, no doubt, large pockets of this valuable mineral will be found in the stratified iron-ore beds, locally taking the place of the iron ore, as is often the case in the Clinton beds in Virginia.

Considerable attention has recently been directed to what is known as the Powells Fort manganese mines, located at Powells Fort, in Shenandoah county, on the Northeast Massanutton mountain. This mine has been worked at times for many years. The property is owned by the Manganese and Iron Company of Baltimore, and contains 531 acres, immediately between Three Top mountain to the north and Green mountain to the south. This system runs northeast and southwest, conformably with the universal belt of the Appalachian chain. The following statement is furnished by the company:

There are 2 parallel veins over 1 mile in length, only 1 of which, however, is developed. The mines have been operated at intervals for several years in a crude manner and on a very small scale. During this time considerably over 1,000 tons of ore were shipped. One of the most celebrated manganese experts in the United States carefully examined this property and advised its purchase by the company, as it was the only well-defined vein he had ever seen, the walls being perfectly regular, the hanging conglomerate, the foot wall sandstone. The vein varied in width from 4 to 7 feet, traceable from one boundary of the property to the other by its bold outcrop, which has been opened at several places, showing well everywhere.

The ore is remarkably clean, almost entirely free from foreign matter. It is highly crystallized, very soft, a genuine pyrolusite of high grade, and is nearer chemically pure than any yet found, as will be seen by reference to the following analyses:

ANALYSES OF MANGANESE ORE FROM POWELLS FORT, SHENANDOAH COUNTY, VIRGINIA. (a)

FIRST ANALYSIS.

	PER CENT.
Oxide of manganese (b)	94.30
Moisture.....	0.28
Insoluble siliceous matter.....	1.78
Alumina.....	1.10
Baryta	1.30
Sesquioxide of iron, lime, and manganese.....	0.50
Undetermined matter	0.74
Total	100.00

a By J. Blodgett Britton, of Philadelphia.

b Nearly all binoxide. By the analysis it should be taken as a fully 99 per cent binoxide.

ANALYSES OF MANGANESE ORE FROM POWELLS FORT, ETC.—Continued.

SECOND ANALYSIS. (a)

	PER CENT.
Silica in the form of quartz.....	3.78
Peroxide of iron.....	0.43
Metallic manganese.....	60.66
Oxygen with manganese, undetermined matter, and loss.....	34.09
Alumina.....	0.25
Moisture.....	0.37
Baryta.....	0.42
Total.....	100.00

a By J. Blodgett Britton.*b* By the analysis it should be taken as a fully 90 per cent binoxide.

On what is known as the Guy Run estate, in Rockbridge county, 6 miles southward from Goshen Bridge station, on the Chesapeake and Ohio railroad, quite an extensive deposit of manganese has been discovered. Up to the present time but a few tons have been mined. In its general topography this estate is quite mountainous. The ores are found in the valleys. The manganese lies in close proximity to Rogers No. VII (oriskany) brown hematite ores, imbedded in potters clay, which separates it from the iron ore. It is in pockets more or less persistent along the line of the ore horizon of No. VII.

ANALYSIS OF SAMPLES OF SOLID ORE FROM GUY RUN ESTATE, ROCKBRIDGE COUNTY, VIRGINIA.

	PER CENT.
Mn ₂ O ₄	89.67
Fe ₂ O ₃	4.30
Sulphuric acid.....	1.25
Silicic acid.....	0.79
Metallic manganese.....	64.59
Metallic iron.....	3.01
Phosphorus.....	0.55

In the counties of Appalachia, southward of those already named, many outcrops and other indications of manganese are found. Most of these are now too far from railways to be profitably worked.

At Panther Gap some ore has been mined, though no statement as to amount or the character of the deposit was obtained.

In Craig county several manganese deposits have been opened, but the distance from railroads precluded shipments for a long time. The Craig Valley branch of the Chesapeake and Ohio railroad will give transportation facilities and possibly lead to the development of these ores. These deposits are stated to extend a distance of 17 miles.

Analyses are as follows:

ANALYSES OF MANGANESE ORES FROM CRAIG COUNTY, VIRGINIA. (a)

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Metallic manganese.....	45.000	52.429	49.489	54.060	50.590
Metallic iron.....			6.830	1.820	4.810
Phosphorus.....	0.085	0.303	0.063	0.058	0.026
Sulphur.....			0.010		
Silica.....	4.700	0.469	2.530	1.670	0.580

a Nos. 1 and 2 by T. T. Morrell, chemist of the Cambria Iron Company; No. 3 by S. P. Sharpless, Boston; Nos. 4 and 5 by Vulcan Steel Works, Saint Louis.

In Giles county, in the oriskany measures, the iron ores often give way to manganese. Boyd, in his Resources of Southwest Virginia, says:

In one point on these rocks (oriskany) on Flat Top mountain, near the line between Giles and Bland counties, the ore was found in great purity, containing valuable quantities of manganese disseminated heavily through sandstone.

Analysis of this ore shows 59.215 per cent metallic manganese. Manganese is also found in the Buckeye and Spruce river mountains and at the ore beds of the Sinking creek furnace, as well as at other localities in the county.

In Pulaski county manganese ores of a high grade are found among the oriskany iron ores of Walkers mountain.

The same is true of the extension of these mountains into Wythe county. The manganese ores found in the oriskany rocks of Big Walkers mountain, in Wythe county, are at times quite pure.

In Bland county the oriskany measures in several of the parallel mountain ranges that traverse the country from northeast to southwest show deposits of manganese ores of considerable extent and at times quite pure.

In Tazewell county surface indications are quite frequent, but the developments are not as yet sufficient to give an idea as to the extent of the deposits. Some of the specimens indicate rich and valuable ores.

In Smyth county there are frequent indications of manganese. At one, on the property of Mr. William Alexander, near Holstein Mill, the ore is in bowlders varying in weight from 2 to 300 pounds. Some 20 tons have been taken out at a depth not exceeding 6 feet. An analysis showed 62.57 per cent black oxide of manganese.

HISTORY.

The black mineral known in commerce as "manganese", but which is really an oxide of the metal (MnO_2), was used in the arts many centuries before the beginning of the Christian era. Its earliest uses seem to have been in pottery manufacture and as coloring matter in the manufacture of glass. Analyses of Egyptian and Roman glass show as high as 2 per cent of manganese, and there seems to be no doubt that many preserved specimens of purple and pink glass owe their coloring to the presence of manganese. In later years it has been used both as coloring matter and as a decolorizer in glass making, it giving some of the most beautiful tints to glass, especially purples and pinks. On the other hand, it is used in small quantities in all glasshouses to remove the greenish tinge due to the presence of iron in the glass sand. It is this use of manganese that has given to it the name of "glass makers' soap" (*savon de verriers*).

In 1740 manganese was regarded as an ore of iron. In that year the chemist Pott pointed out that it frequently contained but the merest traces of iron. In 1771 Scheele began a careful chemical examination of it, and proved conclusively in his now well-known dissertation, published in 1774, that it was only an oxide of some metal which he could not produce in a metallic state. It was while engaged in the unsuccessful attempt to reduce this oxide that he made his valuable discovery of chlorine, and it is in the manufacture of this gas for use in the production of bleaching powder that manganese to-day finds one of its chief uses.

Dr. Gahn, a little later than Scheele, in 1774, succeeded in reducing the oxide to its metallic state, and Rinman in the same year pointed out the peculiar effect of manganese on the magnetism of iron, depriving it, when used in quantities in the manufacture of iron, of its usual magnetic property. In 1799 Reynolds attempted to use oxide of manganese in the production of steel, but was unsuccessful, it being reserved for Heath in 1839 and for Mushet some 15 years later to point out the great importance of this metal in the manufacture of crucible and bessemer steel, respectively. It is also true that in the manufacture of the celebrated Indian steel known as "wootz", which probably gives the finest cutting edge of any steel produced, a manganiferous pig iron is used. In later years Mr. Robert Hadfield, of Sheffield, England, has shown the important influence of manganese in large quantities in rendering steel both hard and tough.

It should also be pointed out that as early as 1830 Mr. David Mushet produced ferro-manganese, 35 years before it was produced in a commercial way by Henderson at Saint Rollox chemical works at Glasgow. *Spiegeleisen*, which is a pig iron containing varying proportions of manganese up to in some cases 30 per cent or higher, had also been produced in its lower percentages in Germany and the United States. But little use had been made of it, however, until Mushet pointed out its value as a recarburizer in the manufacture of bessemer steel. While excellent cast steel had been made before Heath's time, and while it was possible to produce bessemer metal by Bessemer's original process of leaving unoxidized in the converter an amount of carbon sufficient to give proper temper to the steel, it nevertheless is a fact that steel has been produced better and cheaper by the use of Heath's and Mushet's inventions than would have been possible by the processes in use before their time.

In 1785 Berthollet pointed out the use of chlorine as a bleaching agent, which, as stated above, had been discovered by Scheele in his experiments on manganese ore in 1774. Its use was introduced into Glasgow as early as 1789 by Watts, a celebrated engineer, and thence found its way to Lancastershire. The chlorine was produced by the action of hydrochloric acid on the binoxide of manganese. At first chlorine was used by the saturation of water with the gas, but it was found that the alkali would soon absorb more chlorine than water; hence the production of bleaching powder. For many years, and until the demand for *spiegeleisen* and ferro-manganese, by far the largest percentage of the production of manganese was used in chemical works for the production of chlorine. The use of manganese at the present time in these works is not as great in proportion to the amount of bleaching powder produced as formerly, methods for recovering manganese from the waste having been discovered.

ORIGIN AND OCCURRENCE OF MANGANESE.

From the close association in which iron and manganese are usually found it is probable that they have the same origin. It is not within the limits of this report to discuss the various theories that have been advanced regarding the origin of iron ores. This is done very thoroughly in Winchell's *Iron Ores of Minnesota*. It is evident, however, that in many parts of the United States the manganese nodules, which form the bulk of the ores, were imbedded in ferriferous shales, and the tenacious clay in which the manganese in many parts of Virginia is found imbedded was formed by the decomposition of this clay. In Arkansas a nodular ore of manganese is found imbedded in an undecomposed shale.

Manganese is usually found in pockets like its cousin-german, brown hematites, usually imbedded in clay and requiring washing. The clays in the horizon of the ferriferous shales are colored brown from the diffused

manganese, while the clays of the deposit in which the manganese is most abundant are red, showing that the gathering of the manganese into masses has left the iron predominant.

The ore occurs as shot ore and in nodules, lumps, and masses, from the size of a pin head to masses weighing tons. "Sheets" of ore are sometimes formed by the union of masses that lie in a uniform direction. These masses are evidently concretionary in their origin. The masses are not only incased in clay, but they often inclose clay. Near Lyndhurst station, Virginia, on the Shenandoah Valley railroad, manganese in the process of formation into lumps has been observed. The ore is psilomelane, with some pyrolusite and manganite, the softer material being found in cavities of the material or forming seams in the harder ore. Lumps and crusts of the manganese may be seen imbedded in the clay, and they are plainly now in process of formation. The manganese seems to be freely diffused through the dark-brownumber and to be gradually concentrated out of the clay in lumps and crusts. In some cases crusts of manganese may be seen inclosing the clay, and the nodules often show inclosed clay.

The base of the Virginia deposits in the Blue Ridge is usually the potsdam; that of the Appalachian district is the Hudson River No. III, Clinton No. V, and Oriskany No. VII.

In the Cartersville (Georgia) district the ore occurs in pockets imbedded in a drift deposit, usually covering hilltops and outcropping, but at times at a depth of from 3 to 30 and even 100 feet below the surface. These deposits are at times bedded with some regularity and at others scattered without the least regularity. There are frequently "leads" running from one deposit to another. The drift in which the ore is imbedded varies greatly, being sometimes ocher, at others a blue dirt, soft and without grit, and at still others it is said to be found in sand rock. These deposits have as their base the silurian rocks, usually the potsdam, and lie near the metamorphic rocks of the state. They are associated with limonite deposits of a similar character, the limonite usually occurring to the west of the manganese.

The ore occurs as massive, crystallized, and needle ore, and is found in grains from the size of a mustard seed to that of a pea and even a walnut, and also in much larger masses.

In Batesville (Arkansas) district it is stated that the ores occur in two horizons and under two distinct conditions:

1. The drift ores of the northwestern portion of the region.
2. The regular stratified bed of the eastern portion of the belt.

The drift manganese ore is found under the tops of the hills in pieces from the size of a pea up to bowlders 2 and 3 and even 4 tons in weight. The diluvian deposit carrying the ore is from 5 to 25 feet in thickness, averaging, say, 9 feet, and rests upon a floor of limestone, a brown clay of varying thickness being interposed. This ore drift yields from 12 to 30 per cent of ore. Above the manganese drift is an earthy wash, interspersed with fragments of chert from 3 to 30 feet thick. At the Southern mine the stripping is 2 to 25 feet thick, and the drift in which the manganese is found 20 feet thick. The pit at this mine covers a little more than half an acre. At other pits opened the stripping is 10 feet and the ore drift 5 to 11 feet.

The source of the manganese ore lumps is believed to be the "cavernous limestone" found to the northwest of the ore belt, which originally occupied greatly elevated positions. Some of the formation near the mouth of Lafferty creek which has escaped the denuding agencies still carries veins of manganese ore 8 to 14 feet thick.

In Nova Scotia the ores of manganese, which are usually of a very high grade, occur most abundantly in the lower carboniferous marine limestone, though some ores are found in the lower silurian.

The carbonate manganese ore of Great Britain is found in truly stratified beds in the cambrian rocks of Merionethshire.

No information is at hand regarding the occurrence of the manganese ores of Chile or Russia, the two chief sources of supply. What information has been secured regarding the deposits in these countries, as well as in Greece, Turkey, Italy, France, Russia, and elsewhere, will be given under appropriate heads.

As the Crimora mine, in the Shenandoah valley of Virginia, is the most important manganese mine in this country, if not in the world, a description of the mine and the mode of occurrence of the manganese will be of interest. (a)

The Crimora mine, the property of the American Manganese Company, limited, is situated in Augusta county, Virginia, 2.5 miles from Crimora station, on the Shenandoah Valley railroad, with which it is connected by a branch road.

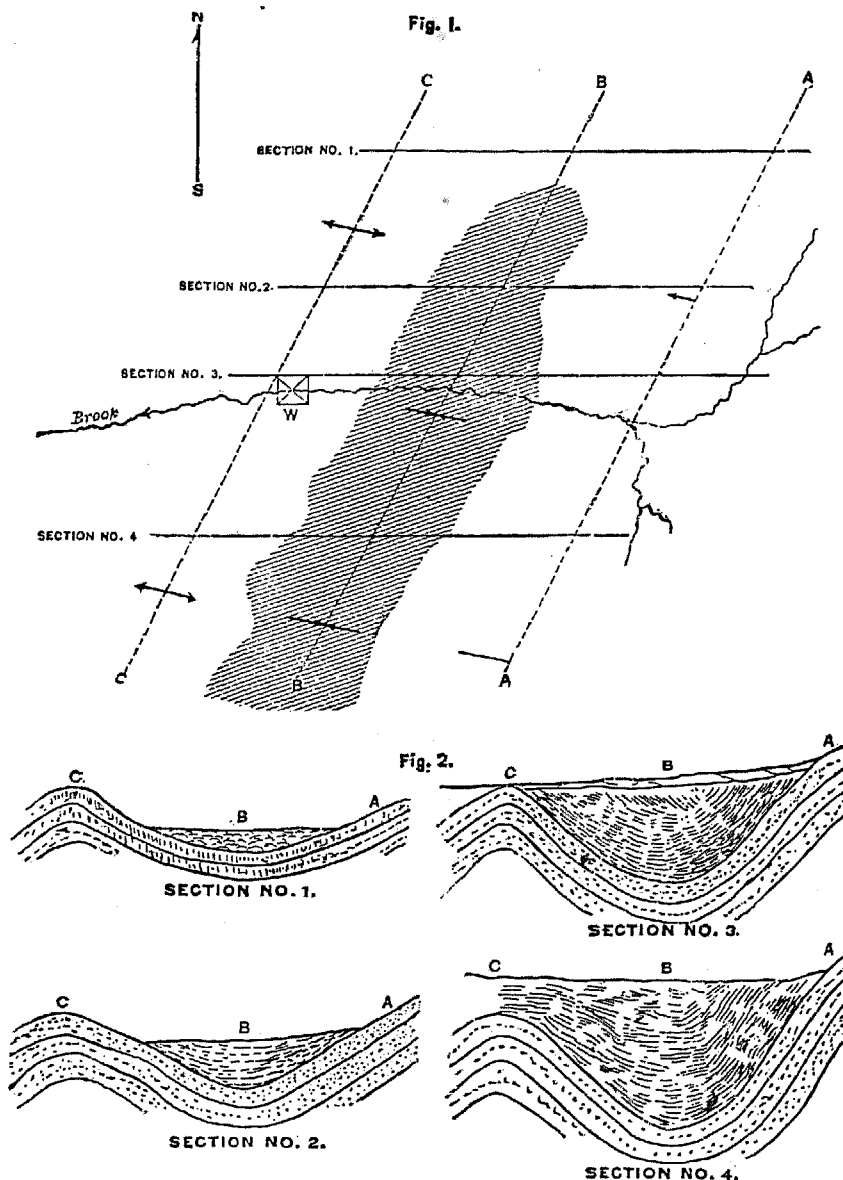
The ore deposit, which is most peculiar in its location and accumulation, occurs in an elliptical basin about 500 feet broad on its transverse axis and 800 to 900 feet long. This basin is cut out of the potsdam sandstone, which is at this place hard rock. Opposite to the basin and at a right angle to its longer axis is a deep ravine, Turks gap, sharply cut into the flanks of the mountain, through which a stream flows. Nearly opposite to this ravine is a ridge that served as a bulwark to the action of the forces at work in this section. Evidently this basin is the work of old time eroding agencies, acting just as water now acts below a river dam, excavating a deep curved section. The formation and location of this basin, as well as the deposit it contains, is exceedingly interesting and peculiar.

^a For much of this description and the cuts credit is due to an article in the American Manufacturer and Iron World, and to a paper read before the American Institute of Mining Engineers by Charles E. Hall.

The basin is filled with wash and manganese ore lumps. The general body mixture, the mud, sand, and clay, with the lumps of manganese ore, were carried to place by agencies more recent than those which excavated the basin, just as the iron-ore pits in the limestone valleys of Pennsylvania were filled in.

There are 2, possibly 3, special layers of yellow clay, which are rich in lumps and masses of ore, the lower about 30 feet in thickness, the upper about 25 feet thick. A layer of clay 20 feet thick, almost barren of manganese ore, separates these 2 ore-bearing layers. The mining operations are at present confined to these beds.

The ore is found in lumps and masses, from the size of a small pebble to lumps weighing a quarter of a ton or more. One mass was found which was 115 feet by 60 feet and 50 feet high. These lumps are found scattered through the basin, as above indicated, and cover an area of about 6 acres. The basin at the shaft is 117 feet deep. Some "sheets" of ore formed by the union of masses that lie in a pretty uniform direction are also found. The larger masses are blasted in the mine.



THE OCCURRENCE OF MANGANESE AT CRIMORA, VIRGINIA.

Figure 1 is a ground plan of the immediate vicinity of the mine. The line AA is the general line of axis of the monoclin of the potsdam sandstone, with westward dip. BB indicates the synclinal axis, which sinks rapidly to the southward. CC is the line of the anticlinal of the potsdam. Near the center of the figure is indicated a brook flowing from the monoclin ridges of the potsdam on the east and crossing the synclinal basin and also the anticlinal fold CC to the westward. W indicates the location of the ore washer. The sections Nos. 1, 2, 3, and 4, Figure 2, are taken on lines indicated by the respective numbers in Figure 1.

It will be seen from Figure 1 that east of the mine there is a large area drained by the brook which crosses the ore basin. This drainage area is principally within the potsdam sandstone belt. The brook leaves the synclinal (ore-bearing) basin at the point where the potsdam anticlinal fold, indicated in the sections by C, sinks below the surface. It will be seen from the sections, Figure 2, that the axis C, as well as B, rapidly sinks to the northward.

The clay resulting from the decomposition of the shales has been preserved within this sharp synclinal. In section 1 scarcely any clay appears, while between sections 3 and 4 more than 300 feet of clay has been penetrated in boring for ore. The shaded portion of Figure 1 indicates the ore area, which extends irregularly northeast and southwest with the axis of the basin. The distance across the basin is one-fourth of a mile. The drainage area of the brook west of the basin is fully 10 square miles.

The fold C, section 3, forms a complete dam, back of which the seepage water is held until it can slowly work its way through the sandstone of C, or southward and past the end of the sinking anticlinal axis.

MINING AND WASHING MANGANESE ORES AT CRIMORA, VIRGINIA.

Regarding the manganese ore deposit at Crimora, the most important in the United States, it is only necessary to say here that the ore is found in an elliptical basin 500 feet broad by 800 to 900 feet long. It is a wash deposit mixed with mud, sand, and clay. The ore varies in size from a pebble to lumps weighing a quarter of a ton or more. The larger masses are blasted in the mine and require no washing. The smaller pieces, to which the clay adheres quite tenaciously, are washed outside the mine and selections made for the home and foreign markets.

Previous to sinking the shafts a number of test holes were drilled in various portions of the estate, to give an idea of the extent and locality of the ore pockets, even when they strike rock, which may not be level.

The shafts were sunk through the clay to below the bottom of the ore and a distance from it, so that their stability will not be interfered with by the mining operations. The main tunnel was also driven outside of and below the ore for a similar reason.

From the main tunnel chutes run out in all directions to the ore pockets, where headings are driven out on the level in various directions. The excavation of the ore proceeds at several levels at once in the same pocket by stoping with timber, as shown, secondary chutes being provided, into which the material from the various levels is dumped, which finds its way to the main chute, and so to the cars. All of the mining is done by hand. Where the material is hard, hand drills and dynamite are used.

The water in the workings is conveyed in wooden troughs to the chutes, where it passes down with the material and partly washes it.

About 300 tons of material are mined in a day of 12 hours, which, after crushing, washing, and separating, leaves about 50 or 60 tons of ore.

The material having no regular formation, but being heavy and loose, necessitates strong timbering of the headings, and the timber is in some places subjected to such a great strain that it has to be renewed about every 30 days. The large quantity needed may be gathered from the fact that about 1,500,000 feet are used in the Crimora mine in a year.

The main tunnel is 7 feet square, inside measurement, having timbers 12 by 12 inches 3 feet apart, which are framed to fit into each other, as shown, to make a firm framework, and have planking or slabs 12 by 2 inches at top and sides to resist the outside pressure.

All material as it comes from the mine is dumped into the chute above the crusher and fed through it. It falls directly into the "log" washer, which consists simply of two shafts about 18 inches diameter and 24 feet long, on which are bolted spiral-shaped teeth, running in a box or frame 24 feet long, 5.5 feet wide, and 3 feet deep, filled with water. From this the material in a semiwashed state passes into the Bradford washer, which is a cylinder 13 feet long and 4.5 feet diameter, with teeth on the inner circumference about 7 inches long. From this it goes into the classifying screen (conical shape) with a mesh of 0.375 inch. All that passes over the screen runs out on the conveyor, and while it is being conveyed into the cars the flint and other refuse matter is picked out. What passes through the 0.375-inch mesh in classifying screen runs by a chute into an elevator, and is then dropped into a jig where all foreign matter is removed, the refuse passing off at the top, and the cleaned ore at the bottom runs into settling tanks and is raised by another elevator and dropped by chute into cars. All machinery works automatically, and the material is not handled after it is put into the crusher.

THE USES OF MANGANESE.

IN POTTERY MANUFACTURE.—As has already been pointed out, the earliest known use of manganese was as coloring matter in the making of pottery and glass. So far as has been ascertained, the first manganese mined in the United States (in Tennessee in 1837) was for use in coloring earthenware. The violets, browns, and blacks of pottery are usually produced with oxide of manganese. The depth of color will depend upon the quantity used and the degree of heat applied. Excess of manganese will color jet black. Basalt or black Egyptian bodies use as high sometimes as one-sixth of the weight of the mass of manganese. Door knobs are colored black by an excess of manganese. Various shades of brown result from using varying proportions, while a slight amount will give a violet or purplish tinge to the ware. The manganese is used either in the body of the ware itself or in the glaze or the decorations. A raw black glaze may require as much as 10 to 15 per cent of manganese.

IN GLASS MAKING.—Manganese, always as pyrolusite in its purest state, is used in glass making for two purposes: first, to color violets, purples, browns, and blacks, and, second, as a decolorizer to remove the greenish tinge due to the presence of iron in the glass sand.

The use of manganese in coloring glass is similar to its use in pottery manufacture. It is employed chiefly to produce violets, pinks, or purples. The coloring properties of this as well as other metallic oxides is greatly modified by the degree of heat to which it is subjected. Not only will different temperatures give different shades of the same color, but even different colors. If the glass which has been colored pink or purple by manganese remains too long in the furnace, it becomes pale or reddish brown, then yellow, and finally green.

As a decolorizer pyrolusite has long been used, and hence its name, "savon de verriers" (glass makers' soap). The amount used will depend upon the amount of iron in the sand, but it is at the largest but a very small percentage of the batch, a half of 1 per cent. The total amount of manganese used in glass making in the United States in 1885 was but 293,850 pounds.

Just how it acts as a decolorizer is a matter of some doubt. It was long believed that its only effect was to change by oxidation the protoxide of iron, which gives glass a decidedly green tinge, to the faint yellow sesquioxide; but Liebig suggests that the effect is not simply chemical but optical, the amethyst color communicated by the manganese counteracting the yellow or greenish-yellow tint of the sesquioxide of iron, into which the protoxide is converted. Mr. Thomas Gaffield suggests that possibly both effects are produced, the manganese giving up a portion of its oxygen and its coloring power to the iron, which is converted into peroxide, giving a yellowish color to the glass, which color is complementary to whatever of purple coloring power is left in the manganese.

As the ores of manganese are usually so intimately associated with iron, great care must be exercised in procuring manganese as free from this element as possible or the substance to be removed will be increased. Great care is also necessary as to the heat of the furnace when using manganese. If the heat is too low, the oxide is not reduced and the glass has a pinkish tinge or "high color", as it is termed, while if the furnace is too hot it is completely reduced, and a greenish or "low color" is the result.

Some deposits of pyrolusite suitable for glass making are found in this country, but most of the deposits worked for manganese contain impurities that unfit it for glass. The manganese from the Crimora mine, Virginia, one of the chief sources of supply of this ore for the manufacture of ferro-manganese, is too high in iron and cobalt for glass. At Mount Athos, in the same state, a deposit is found that meets the requirements of glass making. This ore contains from 90 to 95 per cent of binocide of manganese, 0.02 per cent of iron, and no copper or cobalt.

A manganese much used in the glasshouses of the United States is a very pure pyrolusite from Nova Scotia. Analyses of this ore from the Crystal mine show from 90.50 to 98.05 per cent of binocide of manganese and practically no iron. The ore is crystalline, soft, and easily reduced to powder. Saxony and Turkey are also sources of supply of this material.

IN THE MANUFACTURE OF CHLORINE.—A very large amount of manganese is used in Europe in the manufacture of the chlorine gas used in the production of bleaching powder or chlorate of lime. The production of manganese ore in the United States prior to 1875 was chiefly for use in chemical works, most of it being exported to England. The explorations of Sibert in Virginia in 1859 and of Mills in the same state in 1867-1871 were for manganese for English chemical works.

As has been stated, chlorine was discovered by Scheele while investigating manganese, and was described by him in 1774. In 1785 its value as a bleaching agent was pointed out, and now most of the chlorine used in making the various commercial bleaches is made from manganese.

The ore used is the peroxide. It must be free from impurities that are soluble in hydrochloric acid, especially iron alkalies and alkaline earth. The softer the ore the better. Some ores that are otherwise up to the standard are too hard for chlorine manufacture. The ore must also be rich, 60 to 65 per cent at least binocide, while in some cases 70 per cent binocide or 44.25 per cent of metallic manganese is the lowest that will be accepted.

The method of producing chlorine is simple. Coarsely ground ore is treated in an oblong stone still with hydrochloric acid, at first without the aid of heat, but after 8 or 10 hours steam is forced into the mixture. The process requires 24 hours.

The products are chloride of manganese, water, and chlorine. The chlorine is conducted away in pipes leading from the top of the still. The "still liquor", which contains the chloride of manganese and water, as well as other chlorides with free acid and chlorine, and which was allowed to go to waste until 1855, is now treated, and the manganese recovered as peroxide with but little loss of manganese.

IN THE MANUFACTURE OF BROMINE.—The use of manganese in the manufacture of bromine is analogous to its use in chlorine production. It is made from the "mother liquor" or "still liquor" of salt water after the extraction of the salt. This liquor contains the salt that is not evaporated and the soluble bromine. Sulphuric acid and pyrolusite are added to the liquor, and as a result the bromine is set free. But a small amount of manganese is used in this country for this purpose.

IN THE MANUFACTURE OF STEEL.—It is in the manufacture of steel that manganese finds its greatest demand. In the crucible process it is charged into the pots either in the form of ore at the time of charging, or it is added as

spiegeleisen or ferro-manganese at the time of charging or during the melting, usually toward the close, so as to prevent a too great loss of manganese by oxidation.

In the bessemer and open-hearth processes the manganese is added as spiegel or ferro at or near the close of the process.

The effects produced by the manganese in the manufacture of iron and steel are too intricate and at the same time too much in question to be discussed here. It may be said in a very general way that the manganese prevents ebullition during the solidification of the steel and the formation of blowholes, and also prevents red shortness. It is also used as a recarbonizer in the manufacture of bessemer steel, by depriving it of its oxygen, to reduce the small quantities of oxides of iron formed in the steel during its final melting.

OTHER USES.—Manganese is also used as a paint, as a coloring matter and mordant in dyeing and calico printing, in the manufacture of oxygen, as a material in the manufacture of disinfectants, in electrical batteries, and alloyed with copper, iron, bronze, and other metals for various uses, especially for general bearings.

THE MANUFACTURE OF SPIEGELEISEN AND FERRO-MANGANESE.

Spiegeleisen and ferro-manganese are alloys of manganese, carbon, and iron in varying proportions, spiegeleisen containing the smaller amount of manganese and ferro the higher. Just where the dividing line between spiegeleisen and ferro-manganese should be placed is not determined. In some cases the dividing line is placed at 30 per cent of manganese, in some cases at 20 per cent of manganese, and in others as high as 40 and even 45 per cent. Assuming 30 per cent of manganese as the dividing line, pig iron containing this amount and less would be classed as spiegeleisen; that containing from 30 per cent to, say, 60 per cent of manganese as "low ferro", and from 60 per cent of manganese to as much as 92 per cent "high ferro". The carbon in these compounds varies from 4 to 7 per cent, being as a rule most when the manganese is highest.

Spiegeleisen was first produced in blast furnaces as an accidental product where the burden of the furnace contained more than the usual amount of manganiferous iron ores. As has been pointed out, manganese and manganiferous iron ores often displace in the same mine the true iron ores. When this would happen, and the manganese or manganiferous iron ore would be charged into the small furnaces in use 30 to 50 years ago, the product would be a pig iron with large grains of a whitish color, with brilliant faces sometimes fully an inch square. The Germans gave to this accidental product the name spiegeleisen, or "looking-glass iron", from these large, brilliant facets of crystallization. At many of the old charcoal furnaces in the Shenandoah valley broken pieces of spiegeleisen, so made fully half a century ago, may still be found where they were thrown in the "dump", no use for it being known at that time.

It was the recollection of seeing such irons in Germany and the belief that this crystallization was due to carbon that led Mushet to suggest the use of spiegeleisen as a material for recarburizing in the Bessemer converter. Percy, however, pointed out that this curious form of crystallization was due not to carbon, but to the presence of manganese, showing that when manganese was absent he was unable to find the "specular cast iron" with this characteristic crystallization.

Mushet seems to have been the first who had made ferro-manganese, he having succeeded about 1830 in making a low ferro, containing about 30 per cent of manganese. On page 773 of his *Papers on Iron and Steel*, published in 1840, an analysis of an alloy containing 28.6 per cent of metallic manganese is given.

Mushet does not seem to have made any practical use of his discovery, and it was left for Mr. Henderson, the noted chemist of the Saint Rollox works near Glasgow, to produce ferro on a commercial scale in a reverberatory furnace.

The first use of ferro-manganese in any great quantities was in connection with the Bessemer process for recarburizing. Bessemer first announced his invention in 1856. Shortly after this announcement Robert Mushet took out patents in England for improvement on this process by the introduction of a "triple compound" of iron, manganese, and carbon, which improvement was perfected by subsequent patents by the same inventor.

The spiegeleisen which was at first used contained but from 7 to 8 per cent of manganese with 4 per cent of carbon and 88 per cent of iron. As the use of the Bessemer process increased Mr. Bessemer began to see the necessity of manufacturing ferro-manganese on a large scale for his process, for the reason that it would enable him to make a very mild metal, while the use of spiegeleisen would not permit of such a product, owing to the large quantity of carbon in the pig. Hearing that Mr. Henderson was manufacturing ferro-manganese at Glasgow, he explained to him what was required, when Mr. Henderson at once saw his way clear to the production of the material on a commercial scale, producing shortly a ferro with 50 per cent and gradually increasing it to at least 75 per cent.

It should be said that in the meantime experiments had been made at Terre Noire by Mr. Valton in 1866. The Terre Noire steel works purchased from Mr. Henderson his patent, perfected the process, raised the percentage of manganese from 25 to as high as 75 per cent, and reduced the price 50 per cent, though in 1871 an alloy containing 40 per cent of manganese produced at Terre Noire sold at \$600 a ton.

At first ferro-manganese in commercial quantities was produced by Mr. Henderson in a reverberatory or open-hearth furnace, his product containing in 1865 only from 25 to 30 per cent of metallic manganese. About the

same time, however, a ferro containing 75 per cent of metallic manganese was being made at Cologne by M. Oscar Prieger in a crucible furnace. These methods were used to produce alloys containing the higher percentages of manganese, because it was found at that time that the blast furnace did not give the heat necessary, though the blast furnace could be used for the production of spiegeleisen, in which the amount of manganese contained was small and the consequent heat required low. At the present time, however, all ferro is manufactured in the blast furnace, the greatly increased heats, due to the introduction of the Siemens, Cowper, Whitwell, and other hot-blast stoves, rendering it practicable to obtain in the blast furnace the high temperatures needed for the manufacture of the high ferros. It is necessary, therefore, to discuss only the manufacture of spiegeleisen and ferro in the blast furnace.

Given an ore of proper chemical character, the chief difficulty in the production of spiegeleisen and ferro in the blast furnace is the regulation of the heat.

While a high heat is necessary, say 1,200° fahrenheit, if the blast is heated to a much higher temperature, say 1,400° to 1,500° fahrenheit, there is danger that the silicon may be too high and the product of an inferior quality. Owing to these high temperatures the lining of the furnace is much more quickly worn out than in the case of smelting the ordinary ores.

A considerable portion of the manganese, say from one-fifth to one-third, is wasted in smelting, a portion of it going off into the slag, and another portion in the fumes given off by the furnace. This volatilization of manganese in the furnace operations is a notable characteristic of the production of ferro.

Coke is the best fuel, the consumption varying from 4,800 pounds to 5,000 pounds per ton, the higher grades requiring the most coke. The production of the modern blast furnace is from 34 to 36 tons of ferro-manganese of 78 to 84 per cent per 24 hours, or 230 to 250 tons per week.

For the best working of the furnace in making ferro-manganese a highly basic slag with good fuel and comparatively slow working are necessary. With a basic slag there is a considerable saving in the amount of manganese that enters into the slag, and even with all precautions sometimes over 15 per cent of manganese is lost.

Analyses of the slag show from 28 to 30 per cent of silica, the same amount of lime, and from 20 to 40 per cent of protoxide of manganese.

In this country considerable spiegeleisen is made from the residuum of the franklinite ores of New Jersey after they have been worked for the zinc. This residuum is worked by the New Jersey Ore and Zinc Company, at Newark, New Jersey; the Passaic Zinc Company in Hudson county, New Jersey, and the Lehigh Iron and Zinc Company, at Bethlehem, Pennsylvania.

The following statement, specially prepared for this report by Mr. George L. Stone, of the New Jersey Zinc and Iron Company, treats of these ores and their use in the manufacture of spiegeleisen:

The principal deposit is at Franklin, where there are 2 mines. The Taylor, on the south end of Mine Hill, is owned and worked by the New Jersey Zinc and Iron Company; the smaller mine, on the north end of the hill, is worked by the Lehigh Zinc and Iron Company, and is on the smaller and leaner branch of the vein. The second deposit is at Sterling Hill, about 2 miles from Franklin. There are 2 mines, side by side, on the same vein, owned by the New Jersey Zinc and Iron Company and the Passaic Zinc Company. At present the New Jersey Zinc and Iron Company are not working their Sterling Hill mine.

The principal minerals of the ore are franklinite and willemite, with varying quantities of zincite and calcite. Occasionally the ore contains noticeable amounts of rhodonite and tephroite. The other minerals of the ore are not present in sufficient quantity to be of economic importance. The greater part of the manganese in the ore is in the franklinite, which contains from 9 to 20 per cent; the willemite contains from 2 to 7 per cent. The two silicates of manganese, rhodonite with 42 and tephroite with 54 per cent, are seldom present in sufficient quantity to add appreciably to the value of the ore.

The ore from the Taylor mine contains SiO₂ 9 to 12, Fe₂O₃ 27 to 33, MnO 13 to 18, ZnO 25 to 40, and calcite 4 to 16 per cent. The ore from the north end of the hill is leaner, containing more calcite and rock, and frequently more phosphorus. The Sterling Hill ore contains SiO₂ 4 to 5, Fe₂O₃ 25 to 30, MnO 12 to 14, ZnO 20 to 30, and calcite 20 to 30 per cent. The following are analyses of large lots:

ANALYSES OF STERLING HILL ORE.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO ₂	10.21	11.08	10.33	4.86	5.15	11.77
Fe ₂ O ₃	31.41	27.54	30.36	30.33	27.62	30.91
MnO.....	15.84	17.63	15.95	12.30	13.09	10.27
ZnO.....	32.83	35.88	26.34	28.42	23.38	25.71
Al ₂ O ₃	0.21	0.24	1.16	0.67	0.64	2.01
CaO.....	5.09	2.01	7.15	12.65	14.37	10.43
MgO.....		0.77	1.09		1.98	0.99

Nos. 1 and 2 were selected ore from the Taylor mine; No. 3, lean ore from Taylor mine; Nos. 4 and 5, Sterling Hill ore; No. 6, ore from north end of Mine Hill, leaner than the average.

The ore is all used just as mined, without concentration. At one time the Lehigh company concentrated some very lean calcareous ore by calcining it in an ordinary limekiln and washing out the lime in a log washer similar to those used for iron ores. The results were fairly satisfactory, but they have not continued the practice. An attempt was made at the old Stanhope furnace in 1852 to work these ores raw in the blast furnace, but the zinc blocked the gas flues, which burst, causing a fire which destroyed a large part of the plant. The manager of the furnaces, Mr. Edwin Post, expressed his belief that with properly arranged gas flues there would be no difficulty in working the ore; but the experiment was not repeated there. The old New Jersey Zinc Company made several attempts to work the ore raw in the blast furnace, but none of them were successful. Of late years all the ore has been first treated by the Wetherill process for making zinc oxide, and the resulting clinker, or residuum, alone used in the blast furnace. The clinker is in pieces varying from flat cakes a foot in diameter and about 2 inches thick to fine dust. Formerly it was all screened through screens with a 1-inch square mesh, and only the coarse used for the blast furnace, but at present it is all used, coarse and fine together. The anthracite culm used as fuel in the oxide furnaces contains from 15 to 25 per cent of ash. This and the limestone added nearly make up for the zinc that is volatilized, so that a ton of ore makes just about a ton of clinker. The clinker varies a good deal in composition between the following limits: SiO_2 18 to 25, Fe_2O_3 29 to 36, Al_2O_3 2 to 9, MnO 10 to 20, ZnO 3 to 15, CaO 8 to 16, and MgO 1 to 4 per cent. It is impossible to give an average analysis. The Passaic company makes the least siliceous clinker and the Lehigh the most. Speaking generally, the Passaic clinker is the richest, the New Jersey the next, and the Lehigh the leanest, though at times the order may be reversed.

The New Jersey Zinc Company was the first to make spiegel. Their first furnaces were very small, usually 7 feet bosh by 19 feet to the stock line, with open fronts and open tops. They had tried closed fronts and tops, but did not succeed with them. The Lehigh company's furnace, built in 1881, was the first successful closed front furnace. It was 27 feet to the stock line, with a 4-foot hearth and 8-foot bosh. The top was closed by a hinged cover. This furnace worked very satisfactorily, but the clinker they had at that time was so lean that the make of iron was very small and the cost high. The first of the new furnaces of the New Jersey Zinc and Iron Company was blown in in 1883 and a second in 1885. They have been changed very little since. The Passaic Zinc Company's furnace was also built in 1883. It is about the same height as the others, but wider in the bosh, giving a good deal more capacity. At first the top was closed by a swinging lid, but this not proving satisfactory it was replaced by a bell and hopper.

All the furnaces use Cooper-Durham ovens and return-flue boilers. The Lehigh and New Jersey companies have Dickson blowing engines with 28-inch steam cylinders, and 36-inch stroke. They have not sufficient inlet-valve area, and consequently do not deliver nearly their piston displacement of air. The Passaic company has a Weimer engine, which is more effective.

In making low-grade spiegel the furnaces cut much more in the hearth than when making high grade, as at present, when they are apt to fill up with graphite, which can usually be cleaned out by charging low-grade spiegel scrap to the amount of 10 to 15 per cent of the iron made. The cinder is usually nearly a unisilicate, with about 35 per cent of silica. When the alumina is unusually high, decreasing the lime will usually improve the cinder. The following analyses are of the cinder usually made.

ANALYSES OF CINDER.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
SiO_2	35.77	32.60	37.12	32.59	30.51
Al_2O_3	11.67	13.06	11.72	10.61	12.12
ZnO				0.71	0.82
FeO	2.09	2.85	2.27	1.85	5.26
MnO	9.51	13.07	12.42	8.35	6.44
CaO	30.36	30.58	27.24	32.80	32.02
MgO	10.39	7.54	8.84	11.47	13.31
Total	99.79	99.70	99.61	98.38	100.48

Nos. 1, 2, and 3 are from the New Jersey furnaces. No. 1 is normal cinder. No. 2 is unusually basic and No. 3 unusually acid, both containing too much manganese. No. 4 is cinder made at the Passaic furnace in 1889. No. 5 was made at the same furnace in 1890, and is rather remarkable for the high iron together with low manganese.

The worst difficulty in working the clinker comes from the oxide of zinc it contains. This is usually about 5 to 6 per cent, but occasionally as much as 15, which not only requires a good deal of coal in the furnace, but necessitates an elaborate system of dust catchers or condensers and frequent stops to clean them and the gas flues. The New Jersey company has but 1 set of condensers at each furnace and has to stop at least once a week an hour and a half or two hours to clean out. The Lehigh and Passaic companies have each 2 sets, so that 1 can

be cleaned while the other is in use. The condensers used by all the companies are similar. Each consists of a square cast-iron box at top and bottom connected by sheet-iron pipes. The New Jersey and Lehigh companies have 5 pipes and the Passaic 9 in each condenser. Increasing the length of the pipes does not appreciably increase the effectiveness of the condensers. The New Jersey company has 1 large condenser 33 feet high, 4 feet by 6 in cross-section, with inclined shelves, which is much more effective than the pipe condensers. The best means of catching the oxide seems to be sharp turns in the flues and long horizontal flues. At first the Passaic company used wet scrubbers. They were very effective, but were abandoned, partly because they were thought to be the cause of some bad explosions and partly from the difficulty of collecting the oxide carried off by the waste water.

The richness of the oxide in zinc varies in different parts of the flues and condensers. At the Passaic furnace the oxide from the flues at the tunnel head contains about 56 per cent of zinc. The downcomers give the richest oxide, 76 per cent. In the first condenser it contains but 18 per cent; in the remaining condensers it varies from 54 to 60, the richest coming from the third, the poorest from the last. It grows richer again farther from the furnace, containing 66 per cent at the end of the flue. At the New Jersey furnaces the oxide from the flues at the top and from the condensers contains from 63 to 70, the richest being at the burners of the ovens (where there is often a good deal of metallic zinc), averaging 85 per cent. The oxide collected in the ovens and under the boilers is much lighter, and contains but 40 to 50 per cent of zinc. The following are average analyses of the oxide:

ANALYSES OF THE ZINC OXIDE.

COMPONENT PARTS.	No. 1.	No. 2.	No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
SiO ₂	3.06	4.46	9.70
Fe ₂ O ₃ and Al ₂ O ₃	2.18	3.50	5.35
MnO	4.03	4.66	5.45
ZnO	84.50	79.54	50.23
CaO	1.18	1.59	7.98
MgO	1.07	1.39	5.31

Nos. 1 and 2 are from the New Jersey Zinc and Iron Company and No. 3 is from the Passaic Zinc Company.

A large proportion of the oxide is carried off by the escaping gases and lost. The zinc oxide forms a hard ring around the throat of the furnace, which has to be cut off occasionally, a work that is not only very hard on the men, but is apt to cause the furnace to work badly, owing to the large amount of zinc that drops into it. To prevent trouble it is well to charge one or two blanks long enough beforehand to have the extra coal near the tuyères when starting, to charge a large coal blank the last thing before the stop, and to fill on top of the oxide with light charges, such as would be used in blowing in, increasing the burden quite rapidly, so as to get back to the normal in about 36 hours. This will usually prevent any bad effects, even when 2 or 3 tons of oxide are cut off and dropped into the furnace at once. When the furnace works regularly the zinc gives but little trouble beyond requiring a good deal of fuel and necessitating cleaning the flues; but if on account of any accident the furnace is stopped for any length of time, it will chill all through the charge, forming a pasty mass that it is impossible to melt and difficult even to shovel out. Pieces of zinc will often float and burn on the cinder and iron, but it seldom if ever combines with either.

Furnace B of the New Jersey company, as at present lined, is 34 feet 9.5 inches high, 8-foot bosh, 5-foot hearth, and 6 feet at the stock line, with a bell 3 feet 4 inches in diameter. It has cooling plates at the tuyères, taphole, and cinder notch, and sheet-iron jackets, with spray pipes above and below the tuyères. It is seldom necessary to use much water on the bosh. The lining is very light, being but 14 inches thick. The blast is about 4,000 feet a minute (engine measurement), at a pressure of from 3 to 5 pounds, heated to 950°. The furnace above the stock line is inclosed by cast-iron doors hinged to posts. Around the edge of the hopper are holes (with loose covers) through which bars can be passed to cut the accretions of zinc oxide from the walls without danger of cutting into the lining. The gas outlet is 2 feet 6 inches. During 1889 this furnace made 3,478 tons 5 hundredweight 90 pounds of iron, 83 per cent of which contained over 20 per cent of manganese, the average for the year being 21.09 per cent. The clinker yielded 30.15 per cent of spiegel. It required 2 tons 13 hundredweight 67 pounds of coal to make 1 ton of spiegel. The best day's work was 13 tons 8 hundredweight 100 pounds, and the best week's work 85 tons 18 hundredweight 84 pounds, from clinker yielding 35 per cent. The oxide (flue dust) collected averaged 267 pounds per ton of iron. In 1890 the make was 3,197 tons 3 hundredweight 104 pounds, 79 per cent of which was higher than 20 per cent spiegel, the average manganese for the year being 20.93 per cent. The best day's work was 10 tons 16 hundredweight 68 pounds, and the best week's work was 69 tons 19 hundredweight 12 pounds; the average yield of the clinker was 30.53 per cent, and the coal required per ton of iron was 2 tons 12 hundredweight 66 pounds. 266 pounds of flue dust were collected for each ton of iron made. The average length of blast at this furnace has been about 3 years.

Furnace A of the New Jersey company is very similar to B in general form and construction. The hearth and stock line are each 6 inches wider than B. The lining is thicker, 16 inches on the bosh and 24 inches above

the bosh. This extra lining has been a decided improvement, the blasts lasting longer, the furnace working better and being less affected by stops. The cooling arrangements are the same as at B. The principal difference is in the top, the doors at A being inclined and hinged. This construction keeps the entire hopper out of the furnace, which makes it very durable. The original hopper is still in use, and is apparently as good as ever after 6 years' wear. This entire arrangement of the top castings has proved to be the most satisfactory of any that this company has tried. The doors around the top are not only useful for cleaning, but have more than once been the means of saving the furnace when it had formed a "zinc scaffold" just under the bell. Opening the doors gave a chance to get at the trouble, break up the scaffold, and even to take a good deal of it out of the furnace, which could not have been done through the opening between the bell and hopper.

In 1889 A made 3,393 tons 5 hundredweight 80 pounds of iron, averaging 20.62 per cent of manganese. It required 2 tons 12 hundredweight 45 pounds of coal to make 1 ton of iron with clinker yielding 31.12 per cent. The best day's work was 13 tons 2 hundredweight 96 pounds of iron, and the best week's work 85 tons 10 hundredweight 100 pounds. The charge was 92 per cent clinker and 8 per cent of a 50 per cent iron ore, the yield of the whole being 35 per cent. The oxide collected amounted to 260 pounds per ton of iron. In 1890 the make was 3,440 tons 17 hundredweight 46 pounds, containing 20.77 per cent of manganese. The best day's work was 11 tons 15 hundredweight 20 pounds, and the best week's work 78 tons 3 hundredweight 64 pounds. The clinker yielded 32.22 per cent, requiring 2 tons 10 hundredweight 22 pounds of coal for 1 ton of iron. The oxide collected was 251 pounds per ton of iron. The quantity, temperature, and pressure of blast were about the same as at furnace B. The stops for cleaning out are the same at both furnaces, two a week, one of about 15 minutes to clean the flue at the throat, where it is most rapidly choked with oxide, and one of from 1.5 to 2 hours to clean all the flues and condensers. The boiler flues are brushed out twice a day without stopping, but merely shutting off the gas from the pair being cleaned. The oven pipes are cleaned daily by an air blast and scrapers, the 2 ovens keeping 1 man busy cleaning. Each furnace has 5 tuyères, 4 of 3 inches in diameter and 1 of 2.25 inches. Iron coil tuyères are used. The 2 furnaces are so much alike that there is naturally very little difference in their working. A works a little more regularly and economically; B usually makes slightly better iron. Both furnaces were continuously in blast during the 2 years.

The Passaic Zinc Company's furnace is of a radically different shape, the hearth and bosh being much wider in proportion to the height, while the angle of bosh is about the same, making the top of the bosh very near the top of the furnace. The object of this was undoubtedly to get greater capacity in the furnace without increasing the height, which it was feared would cause more trouble from the zinc. The furnace has done excellent work, frequently making 14 tons a day of 21 per cent iron for considerable periods. The years 1889 and 1890, which have been taken for comparison, do not give a fair showing for this furnace, as it was blown out in July, 1889, and blown in again in September of the same year. In 1890 the furnace was stopped for nearly a month, in February and March, owing to a chilled hearth, but since then it has been doing well. In 1889 the furnace was in blast 312 days, and made 3,974 tons of spiegel averaging 21 per cent in manganese. It required 2 tons 12 hundredweight 22 pounds of coal to make 1 ton of spiegel from clinker yielding 31.36 per cent. 31.3 per cent of limestone was used. 324 pounds of oxide were collected for each ton of iron made. In 1890 the furnace did better, in 341 days making 4,210 tons of spiegel, the clinker yielding 32.26 per cent. But 2 tons 9 hundredweight 22 pounds of coal were used to the ton of iron. The limestone was 27 per cent of the clinker; the oxide collected, 220 pounds per ton of spiegel.

The furnace is water-jacketed up to the mantel. The peculiar top is due to the furnace having been built at first to run open top. The bell and hopper were added later, and this arrangement, having worked well, has been kept in use. The blast averages 3,140 cubic feet per minute (engine measurement), at a pressure of 5 pounds and a temperature of 850°, blown through 5 tuyères 3 inches in diameter. While this is apparently a good deal more blast than is given to the smaller furnaces of the New Jersey company, yet, owing to the greater efficiency of this engine, the difference is the other way.

The New Jersey and Passaic companies use the same coal and limestone. The following analyses show their composition:

ANALYSES OF COAL AND LIMESTONE USED.

COAL.		LIMESTONE.	
	PER CENT.		PER CENT.
Moisture	3.89	Silica	2.81
Volatile combustible matter	4.31	Oxide of iron	1.58
Fixed carbon	79.91	Lime	29.49
Ash	11.89	Magnesia	20.28
		Carbonic acid	45.47

The clinker varied a good deal in composition, but the following analyses are given as fairly representative:

ANALYSES OF CLINKER.

COMPONENT PARTS.	1889.	1890.
	<i>Per cent.</i>	<i>Per cent.</i>
Silica	20.14	18.43
Alumina	4.44	8.65
Oxide of iron	31.37	30.13
Oxide of manganese	15.96	13.18
Oxide of zinc	3.76	4.43
Lime	15.61	14.67
Magnesia	2.59	3.20

The furnace of the Lehigh Zinc and Iron Company as at present lined is much like the New Jersey furnaces in shape. It is wider and about the same height. The hearth below the tuyères is surrounded by coil plates. From the tuyères to the mantel the lining is but 9 inches thick, and is cooled by vertical pipe coils. The top is watercooled by coil plates extending 3 feet 6 inches below the hopper. Instead of the doors around the top used in the other furnaces, the entire bell and hopper of this are hoisted out and run to one side, suspended from a trolley on an overhead track. This arrangement is said to be very satisfactory. The clinker is very siliceous. The following are the average analyses:

COMPONENT PARTS.	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Silica	27.66	25.13
Oxide of manganese	13.46	13.47
Oxide of iron	35.77	33.24
Oxide of zinc	5.93	5.63

The Lehigh company finds it advantageous to use part iron ore, and make low-grade spiegel. The ore used is "blue billy" (burnt pyrites) from acid works. It contains silica 7.90, oxide of iron 78.00, phosphorus 0.009, and sulphur about 2 per cent. The coal is of about the same quality as that used at the other furnaces. The limestone is a very clayey dolomite, containing silica 6.46 per cent; alumina, 7.52 per cent; lime, 28.58 per cent; magnesia, 15.66 per cent, and phosphorus, 0.019 per cent.

Two stops a week of about half an hour each are made to clean flues. The average length of blast is about 18 months. The oxide averages 49.5 per cent of zinc.

The blast is 3,540 cubic feet per minute (engine measurement), at a pressure of from 4 to 5 pounds, heated to 900°, blown through 6 3-inch tuyères. In 1889 the furnace made 3,238 tons of spiegel averaging 12.20 per cent of manganese. The fuel, one-eighth coke, was 3 tons 3 hundredweight per ton of iron; the charge averaged 81 per cent clinker and 19 per cent ore, with 62 per cent limestone. The yield was 33.73 per cent. 264 pounds of oxide were collected for each ton of iron made.

In 1890 less ore was used and the clinker was much richer. 3,670 tons of spiegel were made, 883 tons of which contained 20 per cent of manganese, the remainder containing 12.50. Less than 2 per cent of coke was used, the fuel averaging 2 tons 11 hundredweight 67 pounds per ton of spiegel. The ore mixture (93 per cent clinker, 7 per cent ore) yielded 37.19 per cent. But 50 per cent of limestone was used. 228 pounds of oxide per ton of iron were collected.

It is difficult to make any comparison of the work done by these furnaces with large iron furnaces, owing to the great difference in the yield and character of the ore. Rapid driving is undoubtedly advantageous, making both a cheaper and better product. It is impossible to compare the rate of driving by means of the number of cubic feet required to produce 1 ton of iron, owing to the difference in the yield, or by the weight of fuel burned per square foot of hearth, owing to the difference in the proportion of hearth area to volume, but comparison can be made as to the length of time the stock is in the furnace, or, what amounts to the same thing, the number of tons of stock worked per day for each 100 cubic feet in the furnace. At these furnaces it varies from 4.44 tons at the Lehigh to 5.72 tons at the Passaic, while at the large Edgar Thompson furnaces it is about 5.

The following table gives a comparison of the work of the 4 furnaces for the years 1889 and 1890:

COMPARATIVE STATEMENT OF FURNACE WORK.

ITEMS.	New Jersey A furnace.	New Jersey B furnace.	Passaic.	Lehigh.
Cubic feet in furnace to stock line	1,243	1,134	1,443	1,545
Iron made per day (in tons, hundredweights, and pounds).....	9 7 27	9 2 101	12 7 67	9 9 29
Cubic feet per ton of iron per day	123	124	116	163
Yield of clinker (per cent)	31.36	30.34	31.86	25.48
Fuel per ton of iron (tons)	2.57	2.66	2.73	2.84
Per cent of limestone	23.69	23.80	29.16	56.00
Stock per day per 100 cubic feet (tons).....	4.95	5.44	5.72	4.44
Approximate weight of cinder per ton of iron (tons).....	2.34	2.44	2.34	2.47

The analyses of the spiegeleisen made by the New Jersey Zinc Company from these ores is as follows:

ANALYSES OF SPIEGELEISEN MADE BY THE NEW JERSEY ZINC COMPANY.

COMPONENT PARTS.	No. 1.	No. 2.
Manganese	11.586	11.67
Iron	83.250	83.23
Silicon	0.367	0.99
Phosphorus.....	0.196	0.19
Carbon	4.632	4.02
Total	100.031	100.10

The production of spiegeleisen and ferro-manganese in the United States from 1872 to 1890, inclusive, is as given below:

PRODUCTION OF SPIEGELEISEN AND FERRO-MANGANESE IN THE UNITED STATES FROM 1872 TO 1890, INCLUSIVE, IN TONS OF 2,000 POUNDS.

1872	4,072	1882	21,963
1873	3,930	1883	24,574
1874	4,070	1884	33,893
1875	7,832	1885	34,671
1876	6,616	1886	47,982
1877	8,845	1887	47,598
1878	10,674	1888	54,769
1879	13,931	1889	85,823
1880	19,603	1890	141,162
1881	21,086		

The production of 1872, 1873, and 1874 was entirely from zinc residuum ores. The production at the present time is from zinc residuum ores from native and imported manganese and manganiferous iron ores.

The imports of spiegeleisen and ferro-manganese have been as follows:

IMPORTS OF MANGANESE AND SPIEGELEISEN FOR 1876, AND FROM 1883 TO 1890, INCLUSIVE.

YEARS ENDED—	Spiegeleisen. (Long tons.)	Value.
June 30, 1876.....	3,391	\$6,967
1883 (a)	67,881	1,991,945
1884	94,210	2,353,368
1885	65,496	1,557,103
1886	99,426	2,188,363
1887	150,205	3,327,128
1888	103,973	2,262,600
1889	93,632	1,757,035
1890	108,771	3,032,006

a Not separately classified from 1877 to 1882, inclusive.

CHROMIC IRON ORE.

CHROMIC IRON ORE.

The production of this substance is carried on in an exceptionally irregular way because the 2 companies that make the bicromates of sodium and potassium from it are independent of the domestic product and can obtain as much as they need from Turkey and Asia Minor. At present the ore is produced only in California. It occurs there in many counties very irregularly, in disconnected masses imbedded in the country rock, serpentine, and in uncertain quantities. The quality of the ore is lower than that of Turkey.

STATISTICS OF CHROMIC IRON ORE PRODUCTION IN CALIFORNIA AT THE ELEVENTH CENSUS.

Product (long tons).....	2,000
Value delivered at San Francisco.....	\$30,000
Number of employes.....	30
Number of mines.....	6
Total expenditures for wages.....	\$6,000
Other expenditures.....	\$4,000
Total capital invested.....	\$8,000

The value given above is that in San Francisco. This is given because an average value at the mines would be absolutely without meaning, since a great and variable item of expense is the wagon hauling before rail shipment, as shown by the following analyses of the cost of the ore carried to New York or Philadelphia, where it is consumed:

COST PER TON OF CALIFORNIA CHROMIC IRON ORE LAID DOWN IN NEW YORK.

COUNTIES.	Per cent of ore.	Total.	Royalty to owners.	Mining.	Hauling.	Freight to San Francisco.	Carting to ship.	Interest and insurance.	Freight to New York.
Del Norte.....	45	\$17.25	.....	\$3.00	\$3.00	\$4.50	\$0.75	\$1.00	\$5.00
Placer.....	52	20.95	\$0.25	3.00	8.00	3.00	0.70	1.00	5.00
San Luis Obispo.....	47	17.40	2.00	3.00	2.55	3.85	.....	1.90	5.00
Shasta.....	45	17.50	2.50	3.00	1.00	4.25	0.75	1.00	5.00
Tehama.....	45	18.25	2.00	1.50	3.50	3.00	2.25	1.00	5.00

HISTORY.

The occurrence of chromic iron ore in the United States has been known from the early part of this century, having been discovered by Mr. Isaac Tyson on his farm at Bare Hills, Baltimore county, Maryland, about 1823. From this time to 1845 ore was shipped by Mr. Isaac Tyson, jr., to England more or less irregularly, this being the only market for it. The original discovery was soon exhausted, and, the trade with England being established, inquiry for new deposits was instituted. Valuable ore was discovered at Soldiers Delight, Baltimore county, and in Harford and Cecil counties, Maryland; also in Lancaster, Delaware, and Chester counties, Pennsylvania. Whenever a deposit was discovered Mr. Tyson investigated it, and if valuable obtained control of it. The discoveries increased so rapidly that Mr. Tyson, fearing more deposits would be found than he could control and thus the market in England become overstocked, set about to create a home demand for the ore. In 1845 he established works for utilizing chromic iron ore, which monopolized this industry in the United States, owing to secret modifications of the usual process of manufacture, until within the last few years. In addition to the localities above mentioned, sporadic occurrences of this ore have been reported in New York, Massachusetts, Vermont, Virginia, and North Carolina, but from none of these has any ore been produced. About 1873 Mr. Tyson was informed that a discovery of this ore had been made in Del Norte county, California. He sent a surveyor to investigate the reported find, but it proved to be of no value. Strange to say, however, a large deposit of chromic iron ore was found in another part of this county by the same surveyor, which has been a productive source of chromic iron ore until the present time. Since this discovery it has been found in more than one-half the counties of the state, and has been mined to a

considerable extent in Alameda, Del Norte, Eldorado, Napa, Placer, San Luis Obispo, Shasta, Sonoma, Tehama, and Tuolumne counties. In 1886 the production of the eastern mines was 100 tons. Since that year they have been abandoned, the entire domestic product coming from California.

The product of chromic iron ore in the United States since 1880 has been as follows:

PRODUCTION OF CHROMIC IRON ORE IN THE UNITED STATES FROM
1880 TO 1889, INCLUSIVE.

YEARS.	Quantity. (Long tons.)	Value. (a)
1880.....	2,288	\$27,808
1881.....	2,000	30,000
1882.....	2,500	50,000
1883.....	3,000	60,000
1884.....	2,000	35,000
1885.....	2,700	40,000
1886.....	2,000	30,000
1887.....	3,000	40,000
1888.....	1,500	20,000
1889.....	2,000	30,000

a Subsequent to 1886 the value given is for ore delivered in San Francisco.

FOREIGN SOURCES.

The principal foreign sources of chromic iron ore are Turkey, Russia, and Asia Minor, the last of which contains the largest known deposit in the world. This was discovered in 1848 by Professor J. Lawrence Smith, and is located near Brusa, a town 57 miles southeast of Constantinople. Another large deposit was discovered by him near Harmanjick, about 15 miles farther south, and still another field exists near Antioch. In these beds the ore occurs in masses rather than veins, being found in pockets in serpentine, similar to the deposits of California. The ore mined here is transported by camels to the seaports, whence it is shipped to England, Scotland, France, and the United States. The grade of this ore is higher than our domestic ore, large shipments averaging over 52 per cent of chromic oxide.

The Russian ores are found largely in the soapstones of the Ural mountains. Gustav Rose classifies them under 3 heads: (1) those which occur in large granular masses in serpentine, (2) those which are disseminated through rock, and (3) those found in platinum and gold washings. In Siberia it is found in masses, with lamellar or granular structure, at Orenboorg. It also occurs in extensive beds in Orsova, Drontheim, and Roeraas, Norway. Among other places where chromic iron ore occurs in workable quantities are New Zealand, New Caledonia, Victoria, New South Wales, and Queensland.

IMPORTS.

The imports of chromic iron ore into the United States since 1884 have been as follows:

CHROMIC IRON ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE
UNITED STATES FROM 1884 TO 1889, INCLUSIVE.

YEARS ENDED—	Quantity. (Long tons.)	Value.
June 30, 1884.....	2,677	\$73,586
1885.....	12	239
1886.....	3,356	43,731
1887.....	1,404	20,812
1888.....	4,440	46,735
Dec. 31, 1889.....	2,875	27,382

USES.

As already stated, the production of this mineral is determined altogether by the demand for potassium bichromate and the corresponding sodium compound. Lately the manufacture of sodium bichromate has greatly increased. A small quantity of the ore is used in making chrome steel. Within the last 2 years a process has been gaining favor of making the lining of open-hearth steel furnaces of chromic iron ore. If this is generally introduced, it will completely change the condition of the industry, as the high quality desired where the ore is to be decomposed in making bichromates is not necessary in those for lining hearths. The run of the California mines can be shipped east and then sorted, the poorer ores going to the new use.

ANTIMONY.

ANTIMONY.

BY E. W. PARKER.

PRODUCTION.

The amount of antimony ore produced in the United States in 1889 was 265 short tons. Of this amount 200 tons were mined in Nevada and 65 tons in Arkansas. The Nevada ore is smelted in San Francisco. That produced in Arkansas in 1889 was shipped to Philadelphia for reduction. The amount and value of the star regulus obtained from the ore was as follows :

AMOUNT AND VALUE OF STAR REGULUS PRODUCED IN THE UNITED STATES IN 1889.

STATES.	Total ore smelted. (Short tons.)	Star regulus produced. (Short tons.)	Value.
Total.....	265	115	\$28,000
Arkansas.....	65	25	a 10,000
Nevada.....	200	90	b 18,000

a At Philadelphia.

b At San Francisco.

CONDITION OF THE INDUSTRY.

The mining of antimony in Nevada is of a sporadic character, not carried on as a business or with any organized system, but the ore is taken out by residents at odd times, sold to storekeepers in the neighborhood, and by then shipped to San Francisco for smelting. The producing localities are in the vicinity of Humboldt, but the deposits are pockety and to a degree uncertain, which are the probable reasons why there has been no original effort at developing the properties. In Arkansas more systematic effort has been made and considerable development work has been accomplished. This work, however, was but a beginning in 1889, which accounts for the limited product.

LABOR AND WAGES.

Owing to the irregular manner in which the mining of antimony ore in Nevada is carried on, it is impossible to give a statement of the labor and wages. The following figures are for the work done in Arkansas:

NUMBER OF EMPLOYÉS, WAGES, ETC., AT ANTIMONY MINES IN ARKANSAS IN 1889.

CLASSIFICATION.	Number employed.	Average wages per day.	Average number of days worked.
Total.....	28		
Above ground:			
Foremen.....	2	\$2.00	275
Laborers.....	5	1.50	275
Below ground:			
Foremen.....	1	2.50	275
Miners.....	12	2.15	275
Laborers.....	8	1.50	275

WAGES AND OTHER EXPENDITURES AT ARKANSAS MINES IN 1889.

Wages (including office force at the mines).....	\$12,218
Paid contractors.....	4,641
Paid for supplies.....	3,859
Other expenses (rent, taxes, insurance, etc.).....	2,504
Total expenditures (a).....	23,222

a Excess in expenditures over value of product is due to the large amount paid for development work.

OTHER LOCALITIES.

Antimony occurs in Kern county, California, in a well-defined vein, but there are no records of any production since 1885. In Iron county, Utah, on Coyote creek, are some remarkable deposits of the mineral. A mine was opened there in 1880, and was worked somewhat during that year and 1881, but owing to the excessive cost of transportation and the low price of the metal the enterprise was not found profitable and was abandoned.

PRODUCTION OF ANTIMONY FROM 1882 TO 1889, INCLUSIVE.

CALENDAR YEARS.	Amount of star regulus produced. (Short tons.)	Value.
1882.....	60	\$12,000
1883.....	60	12,000
1884.....	60	12,000
1885.....	50	10,000
1886.....	35	7,000
1887.....	75	15,000
1888.....	100	20,000
1889.....	115	23,000

USES.

Antimony is an important component in a number of alloys. Though brittle itself, it imparts a peculiar hardness and toughness to many of the softer metals. It is particularly useful in the manufacture of type metal with lead, the antimony not only giving hardness, which is essentially important, but causes an expansion of the alloy at the moment of solidifying, making the casting sharp and better formed in the mold. In making type metal from 17 to 20 per cent of antimony is used. Antimony is also used in the manufacture of britannia metal, babbitt metal, and pewter. It makes gold and silver brittle. Copper is curiously and injuriously affected by it. It is said that one-tenth of 1 per cent of antimony is enough to ruin a good quality of copper. Antimony is an element in a number of compounds used medicinally, tartar emetic being the most important. Pulverized antimony sulphide is used to some extent in the vulcanizing of rubber.

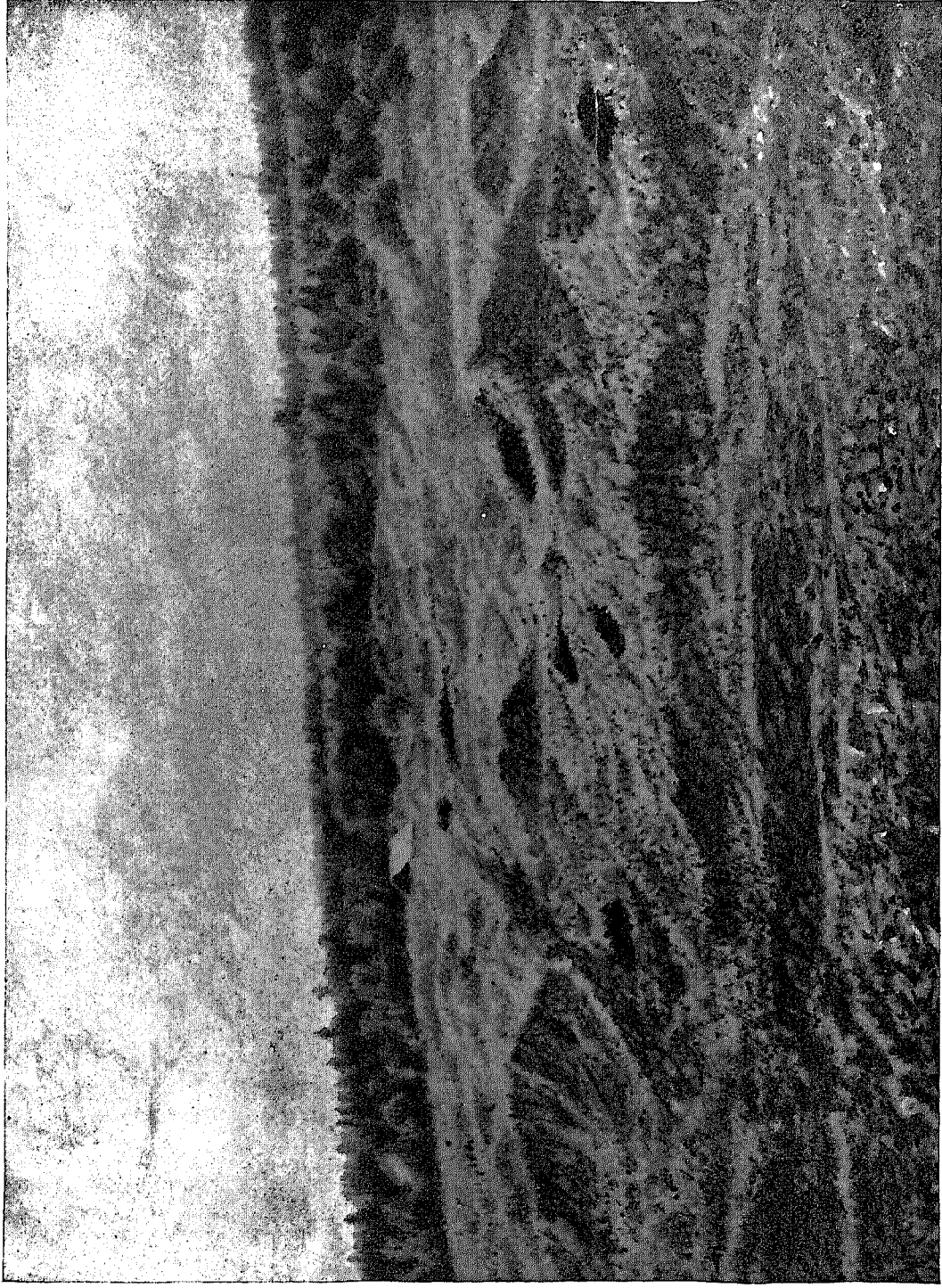
ANTIMONY AND ANTIMONY ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES,
1867 TO 1889, INCLUSIVE.

YEARS ENDED—	Total value.	CRUDE AND REGULUS.		ORE.	
		Quantity. (Pounds.)	Value.	Quantity. (Pounds.)	Value.
June 30, 1867.....	\$63, £19		\$63, 919		
1868.....	83, 822	1, 033, 336	83, 822		
1869.....	129, 918	1, 345, 921	129, 918		
1870.....	164, 179	1, 227, 429	164, 179		
1871.....	150, 628	1, 015, 039	148, 264		\$2, 364
1872.....	240, 567	1, 933, 306	237, 536		3, 031
1873.....	187, 439	1, 166, 321	184, 498		2, 941
1874.....	148, 612	1, 253, 814	148, 409		203
1875.....	131, 969	1, 238, 223	131, 360	6, 460	609
1876.....	120, 141	946, 809	119, 441	8, 321	700
1877.....	197, 631	1, 115, 124	135, 317	20, 001	2, 314
1878.....	132, 200	1, 256, 624	130, 950	20, 351	1, 259
1879.....	145, 440	1, 380, 212	143, 099	34, 542	2, 341
1880.....	268, 122	2, 019, 389	265, 773	25, 150	2, 349
1881.....	271, 253	1, 808, 945	253, 054	841, 730	18, 199
1882.....	312, 253	2, 525, 838	294, 234	1, 114, 699	18, 019
1883.....	298, 146	3, 064, 050	286, 892	697, 244	11, 254
1884.....	156, 924	1, 779, 337	150, 435	231, 360	6, 489
Dec. 31, 1885.....	214, 712	2, 579, 840	207, 215	215, 913	7, 497
1886.....	212, 324	2, 997, 985	202, 563	218, 366	9, 761
1887.....	178, 532	2, 553, 284	169, 747	368, 761	8, 785
1888.....	250, 193	2, 814, 044	248, 015	68, 040	2, 178
1889.....	310, 279	2, 676, 130	304, 711	146, 309	5, 568

PLATINUM AND IRIDIUM.

Eleventh Census of the United States.

Robert P. Porter, Superintendent.



OLD PLATINUM WASHING, NISJNE TAGILSK, EUROPEAN RUSSIA.

(Platinum layer 15 feet below the surface.)

PLATINUM AND IRIDIUM.

The gold-bearing placers of the Pacific coast have long been known to contain iridosmine and other alloys of platinum, osmium, iridium, and others of this group of metals. The grains of iridosmine and flakes of malleable alloys are found in the heavier sands in the undercurrents and riffles in placer mining. As the metal does not amalgamate, it has not usually been saved. In cases where unusual efforts have been made to collect platinum the miners have frequently met with decided disappointment in obtaining a remunerative price; hence little attention is paid to its occurrence, although small amounts are sent irregularly to dealers in San Francisco, who consign the grains to refiners in New York, Newark, or Philadelphia, or to London. In this way 500 ounces of crude material, worth about \$2,000 in San Francisco, were collected in 1889. Of course no statistics of expenses for labor and wages are attainable for this product, as it is always produced as a minor feature in mining gold-bearing placers.

USES.

The principal uses to which this metal is put are the manufacture of crucibles for chemists; quite an extensive use in the manufacture of incandescent electric lights, the connecting wire to the carbon film from which the light is given being of this metal; in the manufacture of artificial teeth, and to a slight extent in the manufacture of jewelry. At one time it was used in coinage in Russia, but owing to the great range of its price commercially this use was abandoned. The metal has been of great importance for crucibles and other chemical apparatus, owing to its high fusing point, being 3,080° fahrenheit.

FOREIGN SOURCES.

The principal source of platinum in the world is Russia, where it occurs in large quantities in the Ural mountains. Originally it was produced here as a by-product of gold mining, as is now done on the Pacific coast; but during late years the gold has become scarce and the platinum has become the principal product of the mines.

The following is a table of the production of platinum in Russia from 1880 to 1887, compiled from the best authorities obtainable:

PRODUCTION OF PLATINUM IN RUSSIA FROM 1880 TO 1887, INCLUSIVE.

YEARS.	Quantity. (Kilograms.)	YEARS.	Quantity. (Kilograms.)
1880.....	2,947	1884.....	2,237
1881.....	2,986	1885.....	2,591
1882.....	4,081	1886.....	4,317
1883.....	3,537	1887.....	4,242

Besides Russian platinum, a small but regular quantity is produced by the French in La République de Colombia. Deposits of this material also occur in Canada and Mexico, but as yet they have not proved commercial factors in its production.

PRICE.

The price of platinum has fluctuated very greatly between 1880 and 1889. In 1880 it was as low as \$5.49 an ounce, while at the close of 1889 it was about \$14 an ounce, and has since risen much higher. This rapid rise in the price is partly attributed to the operations of a syndicate, the decrease in the amount of the ore, and to the fact that labor has become very scarce. According to the Journal of the Society of Chemical Industry, London, England, the product of the Ural platinum mines for the coming 10 years has been sold to certain foreign companies, presumably the syndicate interested in this metal.

The principal supply of platinum is from the two small districts on the slopes of the Ural mountains on the Siberian side. The districts are about 100 miles apart. Each consists of several dried but recent river beds. The northern district, called the Isa, is made of river beds making a local part of the Isa river drainage system.

The other district is composed of similar dry tributaries to the Martin (Martian) river. This district is called the Nisjne Tagilsk district, from the principal village. Both of the districts have been worked for many years. Probably both were originally gold placers, but if so there is nothing to show it, as they are worked for platinum pure and simple. Much has been written, founded largely on guesswork, as to the working of these mines, and to the effect that the rise in the price of platinum is due to failure of the accompanying gold. Whether or not the gold was found and did bear part of the expense, this explanation is of no value, because the producing conditions are now about as they were before platinum rose in value.

The information about these mines has been meager. Fortunately, however, Mr. George F. Kunz has made, at his own inspiration, a trip to this out-of-the-way region, and, making light of sickness and the irksome features of the journey, by untiring efforts against the habitual secrecy of the managers has obtained more information than has been published since the similar journey of von Humboldt. Mr. Kunz was not aided by the government in any way, but arranged to return to the United States just as the report is going through the final revision, and has courteously contributed his difficultly-gotten knowledge to the census report, in order that it may add something to the chance of obtaining platinum in the placers in the United States.

The two districts mentioned above are worked in a similar way, although the northern, Goro-Blagodot, or Isa region is under government control, and the Nisjne Tagilsk or Demidoff district, on the Martin river, is a part of the Demidoff estate, and worked as a purely business enterprise. The Demidoff estate was granted to the prince in order that these placers should be worked.

As shown by the accompanying illustration the deposits are simply placers composed of serpentine and other boulders mixed with chromic iron ore, etc. A favorable flat bed rock is reached at about 30 to 40 feet from the surface, and the platinum sand is found for a depth of 6 to 10 inches on this bed rock. The deposits are opened by shafts to the bed rock and tunnels and side drifts, often 300 feet long, on the bed rock. This tunneling protects the miners in winter. There are hundreds of miles of tunnels on the Demidoff estate. The sand is excavated and piled in the winter and washed in the summer. The process of washing is shown in the accompanying illustration.

On the Demidoff estate there are 3 large washing plants, and a dam for a fourth is being built. Besides this there are many individual workings by peasants, who open small shafts and tunnels to a bed rock and pan the platinum. They give two-thirds to the estate and sell the other third.

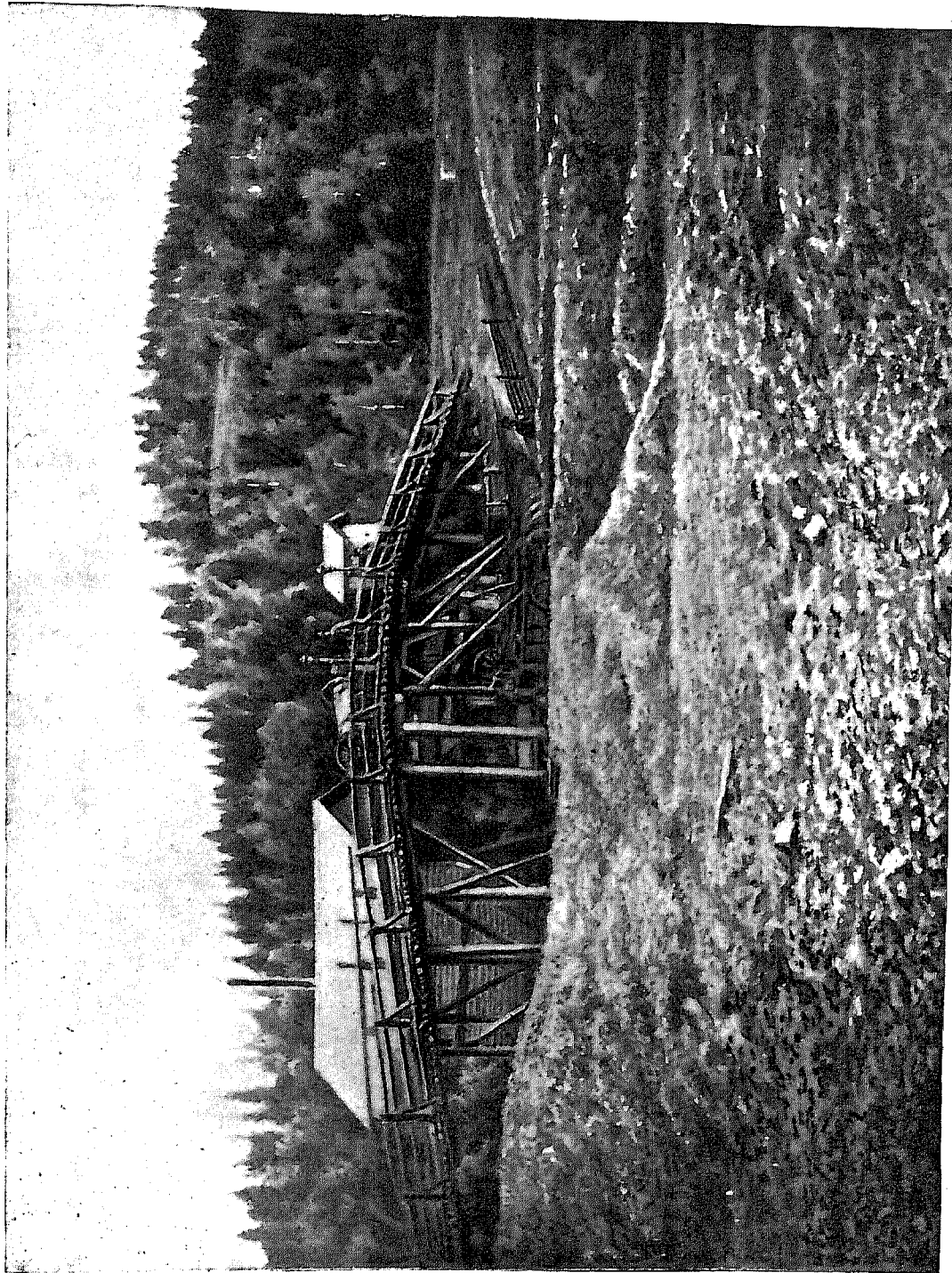
The accompanying illustration gives a general view of one of the three simple washing plants. Carts containing about 1,500 pounds of the pay sand are hauled on the bridge and the contents dumped into a revolving screen below. The small stuff is washed by water. It is stirred by 2 women. The heavier sand, chromite, etc., collects in the riffles. This is worked over again, and the tailings are also washed once more. The machines are run by steam and worked day and night for about half the year. The employes work in shifts of 12 hours each, the day shift working from 6 a. m. to 6 p. m., with 4 hours rest. The night shift also takes 4 hours for rest. The law regarding 8 hours' work is very stringent. The two shifts handle in the course of 24 hours 1,200 loads, or 720 short tons of sand, producing 2.7 pounds of platinum. The daily clean up of the Demidoff estate is about 9 pounds of platinum, including the irregular miners. The wagon driver gets for himself, horse, and cart 1 ruble and 30 kopecks, or from 82 to 90 cents per day, for which he is expected to haul 60 loads. The washing is largely done by women, who get 40 kopecks (20 to 23 cents) a day. The men get 70 kopecks (35 to 40 cents).

DAILY EXPENSE, ETC., OF PLATINUM WASHING IN RUSSIA.

	RUBLES.
40 horses, carts, and drivers, at 1 ruble 30 kopecks	52. 00
16 workmen, at 70 kopecks	11. 20
4 women, at 40 kopecks	1. 60
For one machine	64. 80
Total for the district per day	194. 40
Total milling cost for the year (180 days worked)	34, 992. 00
a \$26, 244.	

The above cost is of course only for the washing. The cost of hoisting and piling the pay sand has not been obtained. The platinum thus produced is about 80 per cent pure, and is worth 8,000 rubles per pood (36 pounds avoirdupois) or \$10 per ounce. It is all purchased by a contract which still has 3 years to run.

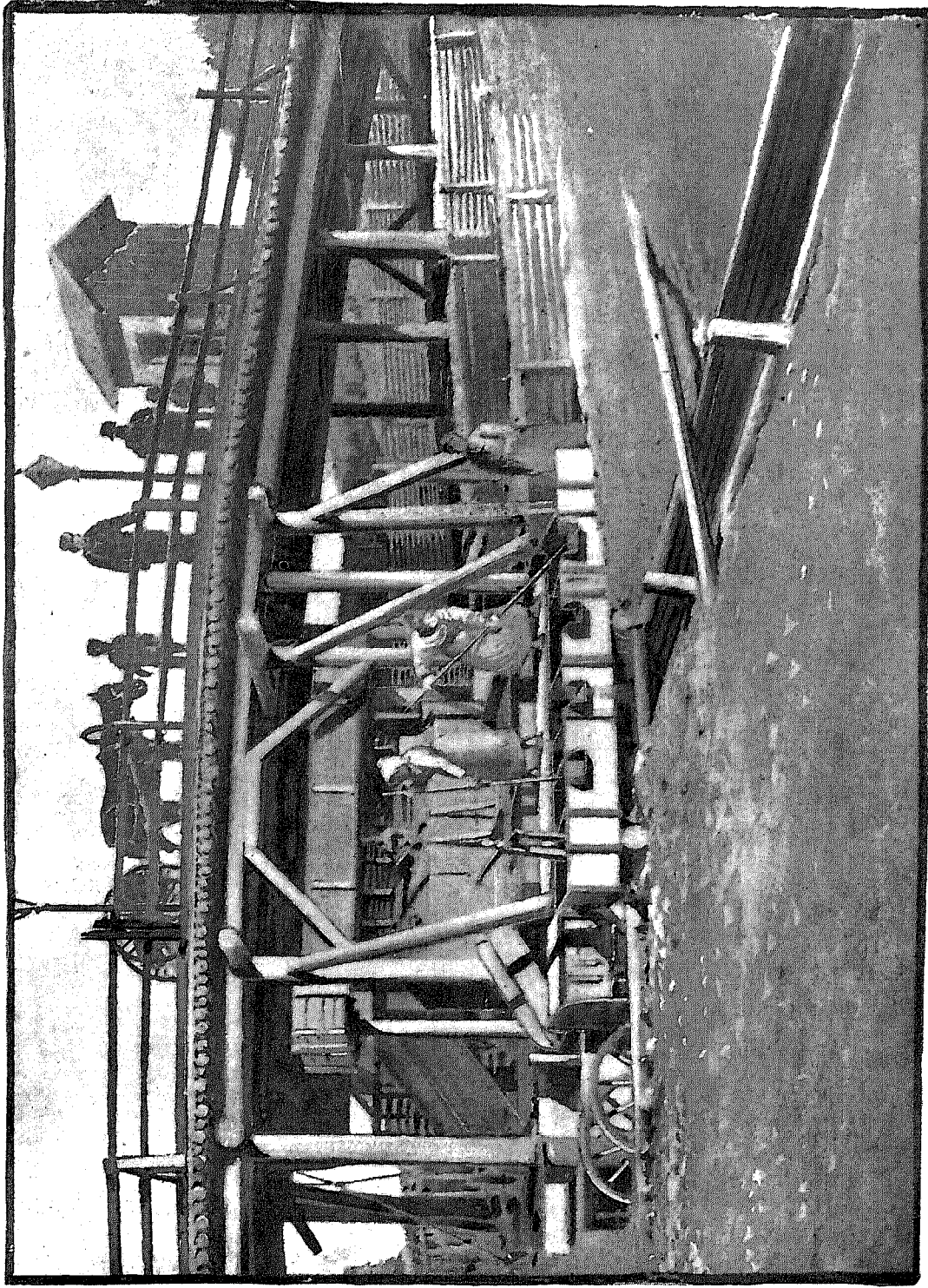
The yearly product of the district amounts to 1,620 pounds avoirdupois, which, at 222 rubles per pound, has a total value of 359,640 rubles.



PLATINUM WASHING MACHINE, DEMIDOFF ESTATE, NISINE TABILSK, EUROPEAN RUSSIA.

Eleventh Census of the United States.

Robert P. Porter, Superintendent.



WASHING PLATINUM SAND, DEMIDOFF ESTATE, NISJNE TAGILSK, EUROPEAN RUSSIA.